ARCH 8903 Final Project

Simulation
Architectural Embodiment

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Master of Science Advanced Architectural Design(19')
Territory of Investigation : Discourse
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00 Abstract

How is an idea processed to generate buildings? Architectural process always requires us to figure out a concept based on the understanding of a complex urban texture, including urban rhythms, temporalities, history, and culture. However, through what medium do we transform those ideas to architecture in the physical world?

I believe that one of the possible media, which enables ideas to embody the design, can be a simulation. As a formula of an architectural discourse, simulation enables us to mimic the reality, create an alternate condition through which we can test the input and output. As technologies develop, the boundary of architecture is becoming broader, yet more categorized. Various new technologies, not only regarding materials or construction technology, but more specific tools such as Computational Fluid Dynamics (CFD), coding, robotic technology, and Augmented Reality (AR) can provide us with a new way of processing architectural designs. Furthermore, these tools help to explore and enhance architectural design processes to create a positive synergy between the design and idea through testing and calculation. This book contains three different academic projects that explore the possibility of simulation as a tool for architectural design from Cornell AAP.

First project explores the possibility of engagement between air pollution and architectural design through Computational Fluid Dynamics (CFD) simulation.

Second project attempts to reshape existing Olmsted Park in Buffalo through Augmented Reality, using 3D Max's liquid surface simulation.

Last project tries to understand the robotic algorithm and computational codes, and to observe how simulation can possibly be exploited to embody architectural ideas.

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Academic Work

01 The Anthropocene Style
Design of Phenomenon; Air Pollution

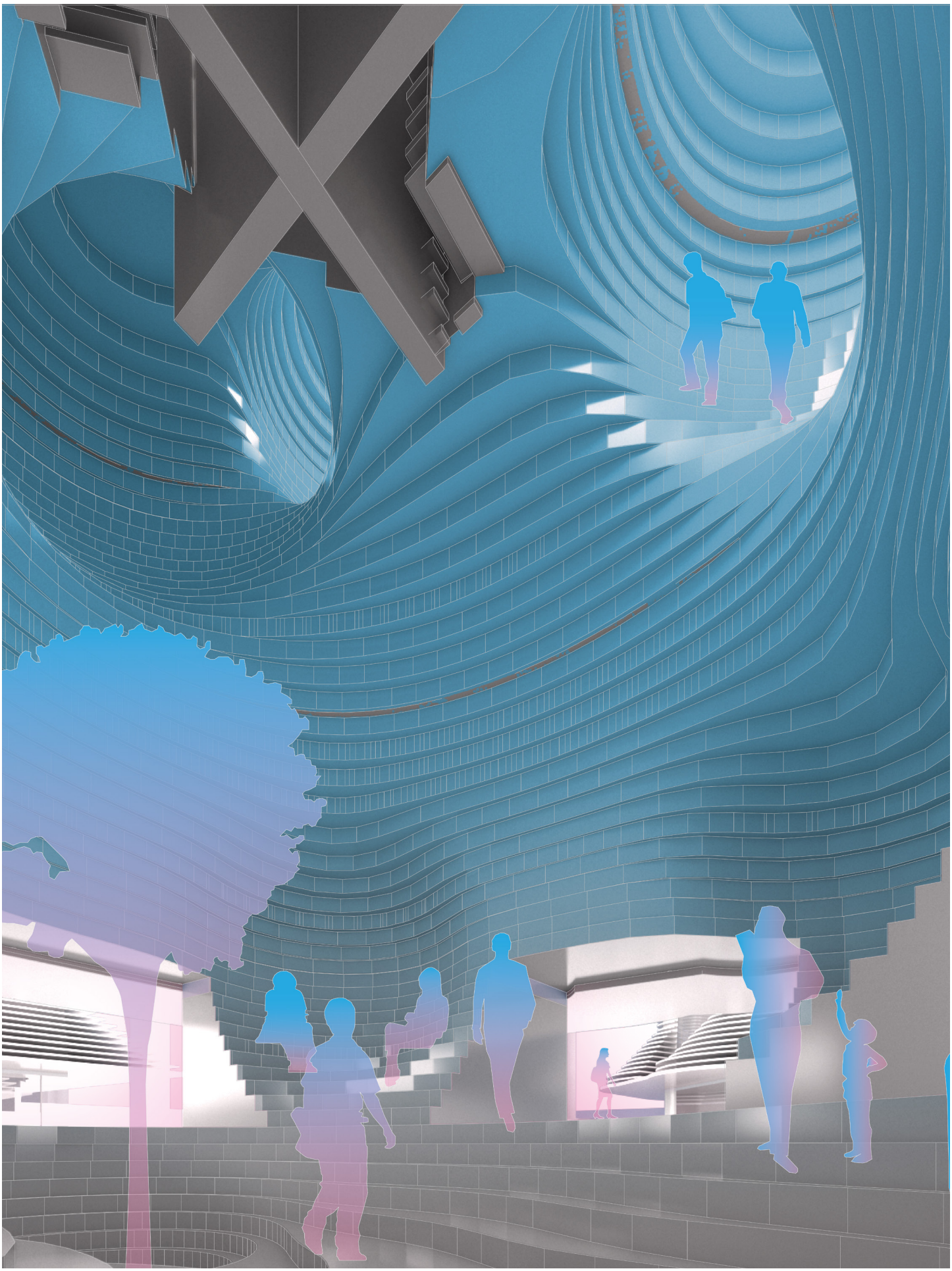
-Cornell AAP
-Option Studio
-Spring 2019

Site : Ithaca(Phase 1 & 2), Geneva (Phase 3)
Instructor : Phillpe Rahm, Sarosh Anklesaria

Conventionally, both architecture and urban design are primarily based on climate, comfort, and health issues. Vitruvius and Alberti write about wind and solar exposures, humidity and temperature rates and how they fundamentally influence architecture. These roots of the urban design were ignored during the 20th century, due to the enormous use of fossil energy by pumps, motors, heating systems and air conditioning that cause various effects today, such as air pollution. The studio focuses on air pollution phenomenon and explores how we can achieve the new architectural style; The Anthropocene Style.

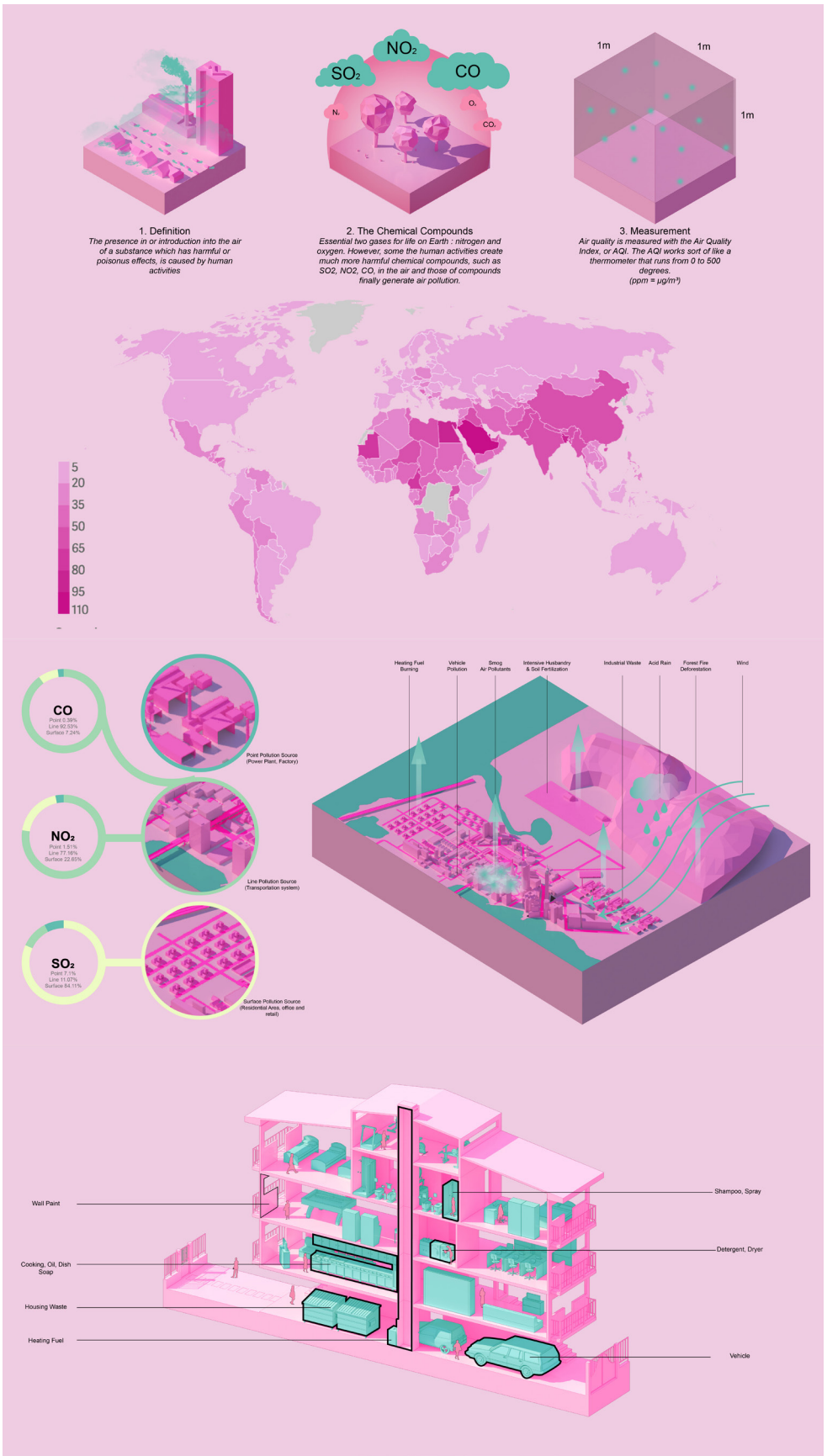
How can architecture be engaged with air pollution phenomenon? The definition of air pollution is the presence of chemicals or compounds in the air, that do not naturally occur. It is mainly caused by diverse range of human activities, such as a single factory (point), vehicles (line), or collective residential areas (surface). According to the research, one of its unique characteristic is that the pollutant in the air mainly spreads through the wind. Therefore, even if the city minimizes pollutants, the pollution will persist because of the pollutants from other areas that keep travel by wind. In this situation, the new architectural design, which shields the public from air pollution, is required.

Thus, the project proposes an air shell design to provide the best air quality for the public. The building design is mainly created through Computational Fluid Dynamics (CFD). The building manipulates wind trajectory and various programs will be located in the building based on the gradation of fresh air. The project shows how simulation can be used to transform the idea of an air shell into a building design and also used as a representative tool to describe the process.



Phenomenon_Air Pollution

Air pollution is mainly created by different range of human activities. The cause of pollutants can be largely categorized into three areas, such as point (Power plant), line (Vehicle) and surface (Residential Area).

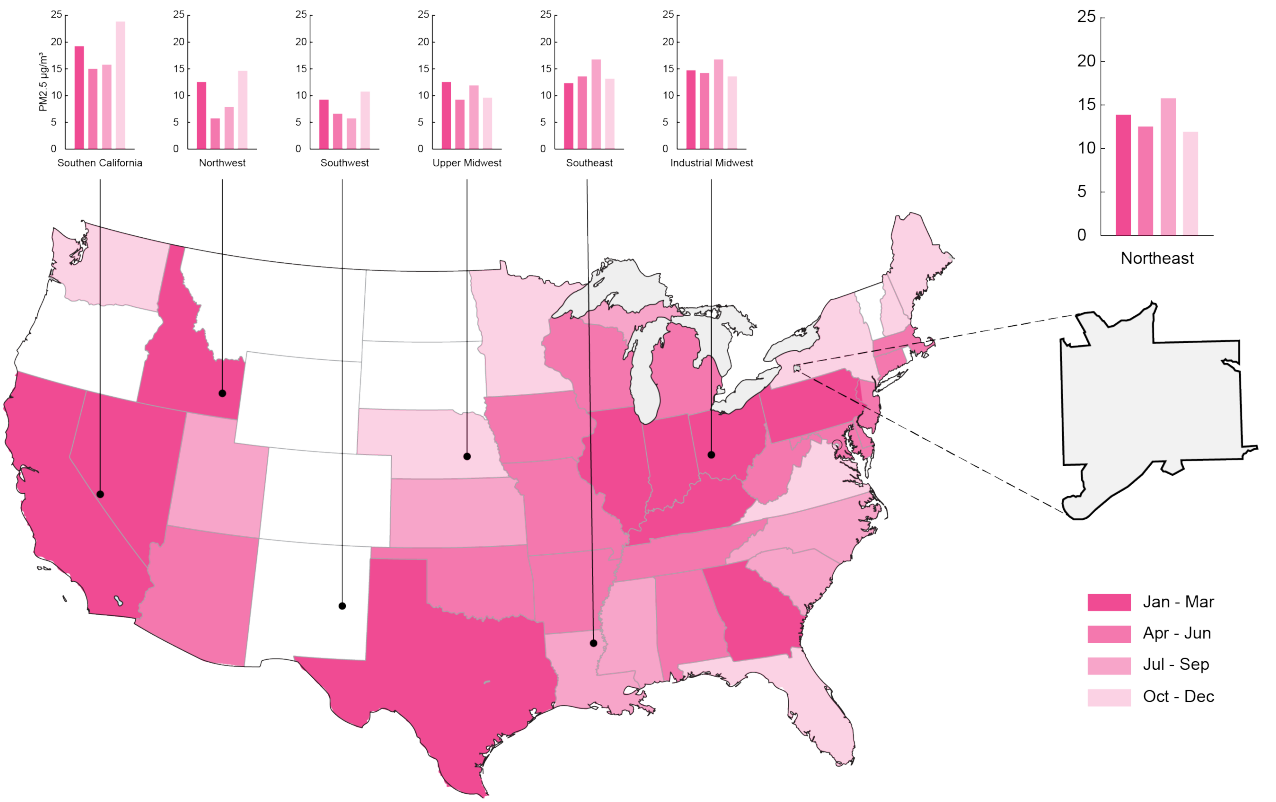


Definition of Air Pollution & Resource

Urban scale to building scale

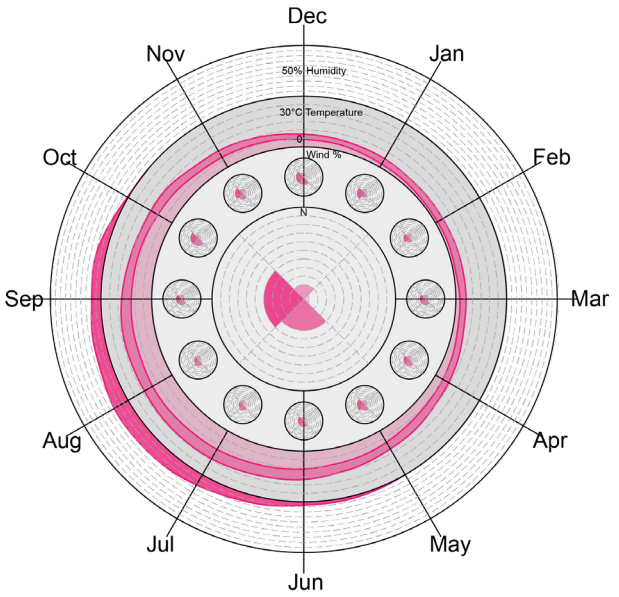
Phase 1_Modular Design in Ithaca

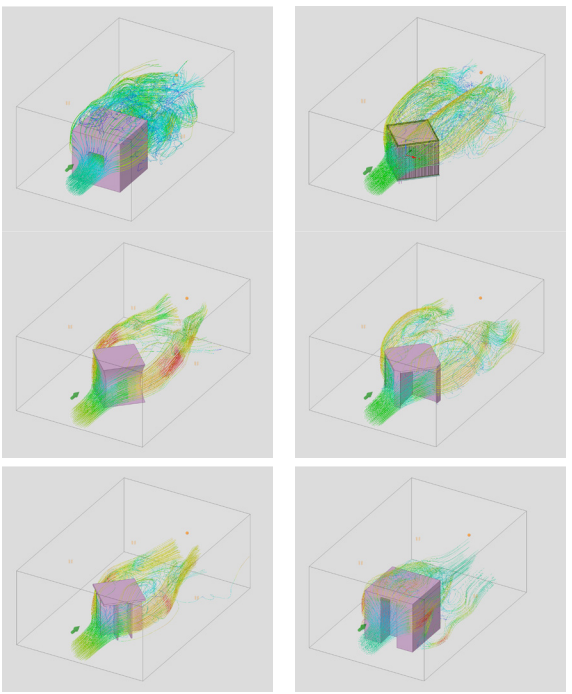
Although Ithaca does not have many pollutants in the city, the dominant pollutant is Particulate Matter(PM2.5). This is because of the Midwest's high density of PM2.5, that is conveyed through the wind. Thus, the design considers how the modular design handles with polluted wind coming from the Southwest.



Particulate Matter(PM2.5) Map

Analysis of seasonal emission density



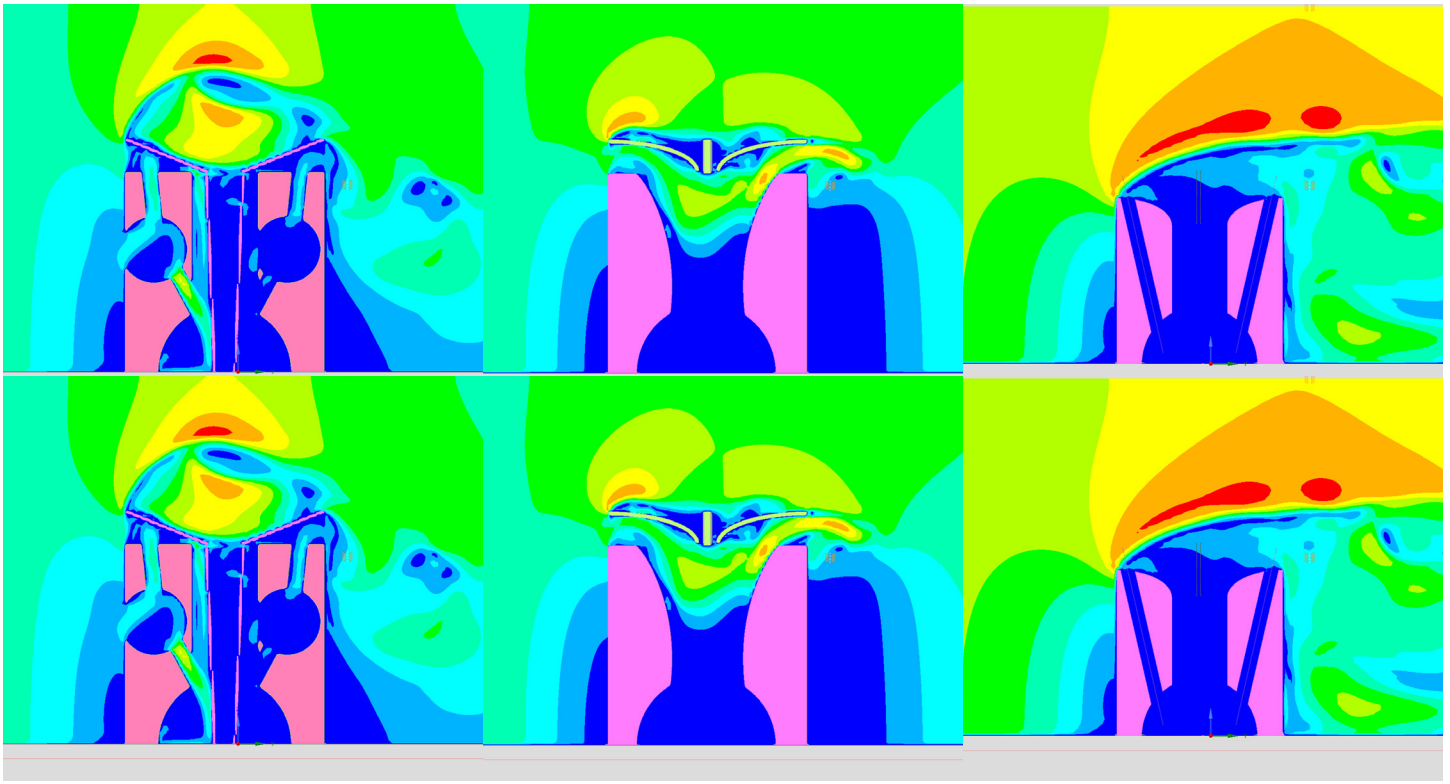


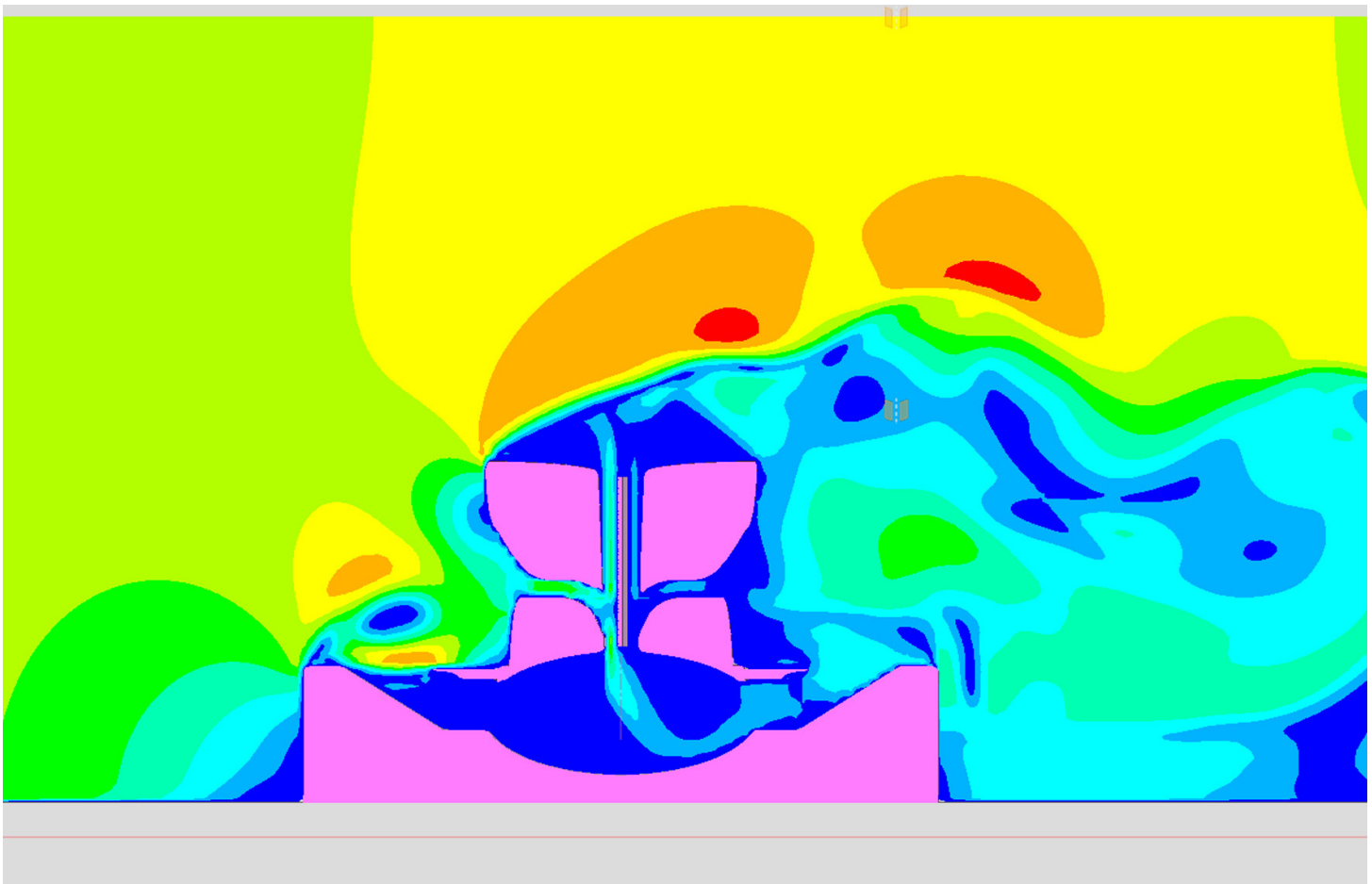
Ithaca Weather & Wind Circulation Simulation

Manipulate pollutant wind direction through building shape

Phase 1a_Single Modular Design

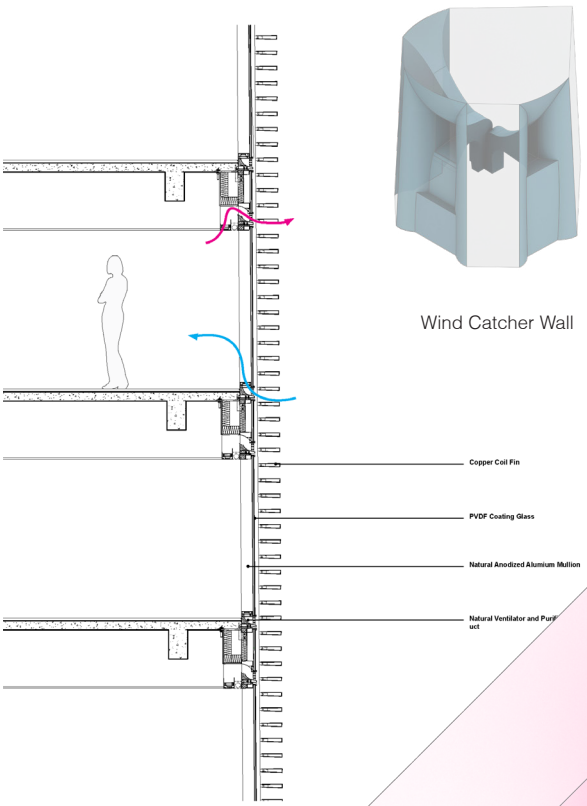
The project's goal is to capture polluted wind on the higher level, purifying it in the middle, and releasing the purified wind to the public space on the ground level. Computational Fluid Dynamics(CFD) explores the best quality of air flow condition based on building shape.



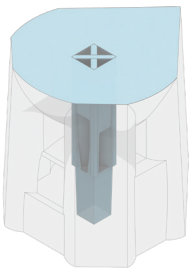


CFD Simulation: Module 1

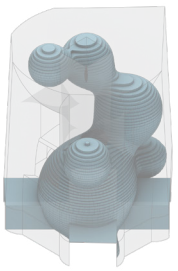
Simulation for testing the wind circulation to achieve best shape of air cell design



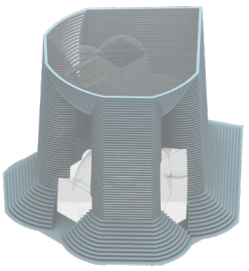
Wind Catcher Wall



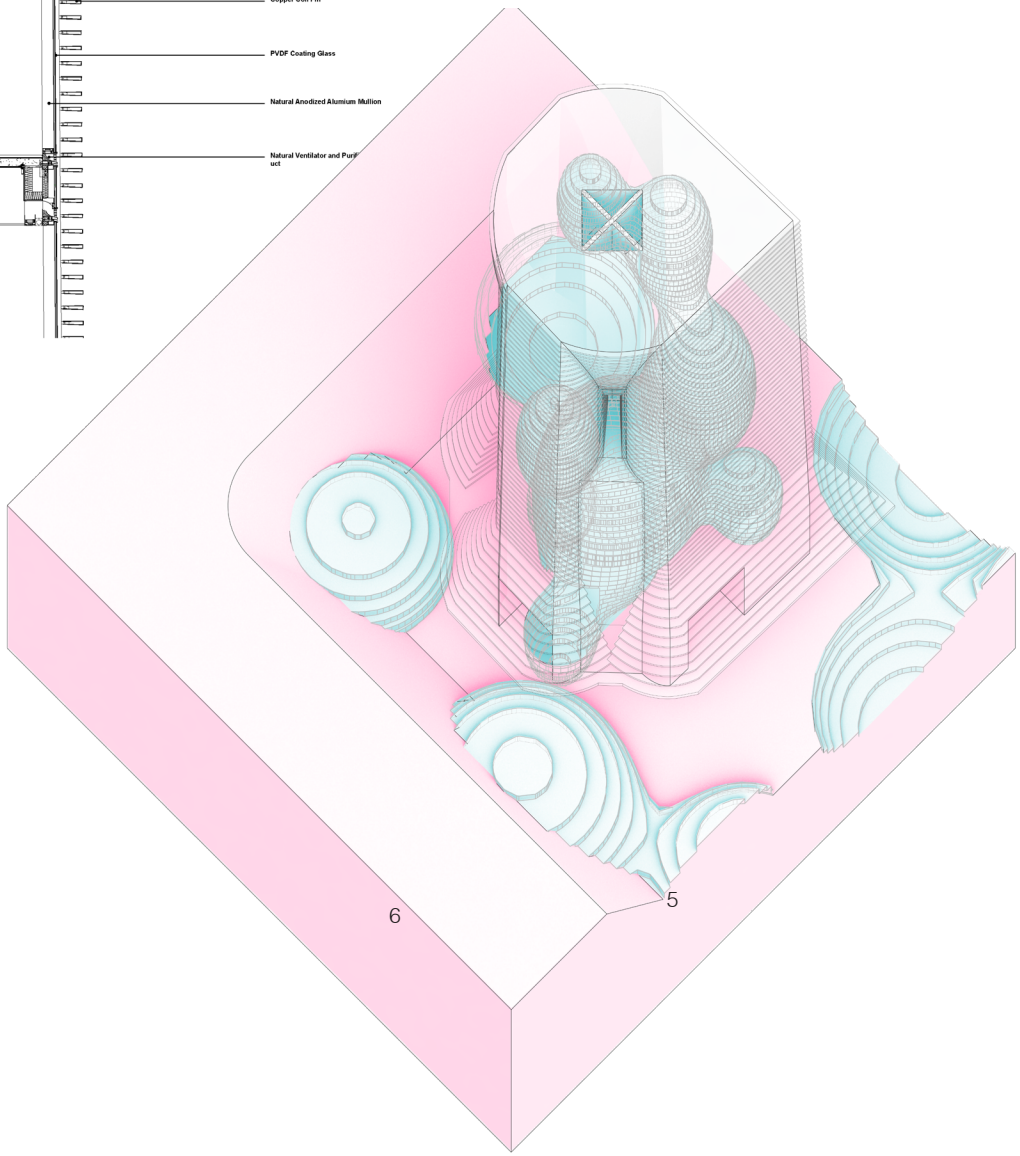
Water Collector



Air Cell



Copper Coil Facade

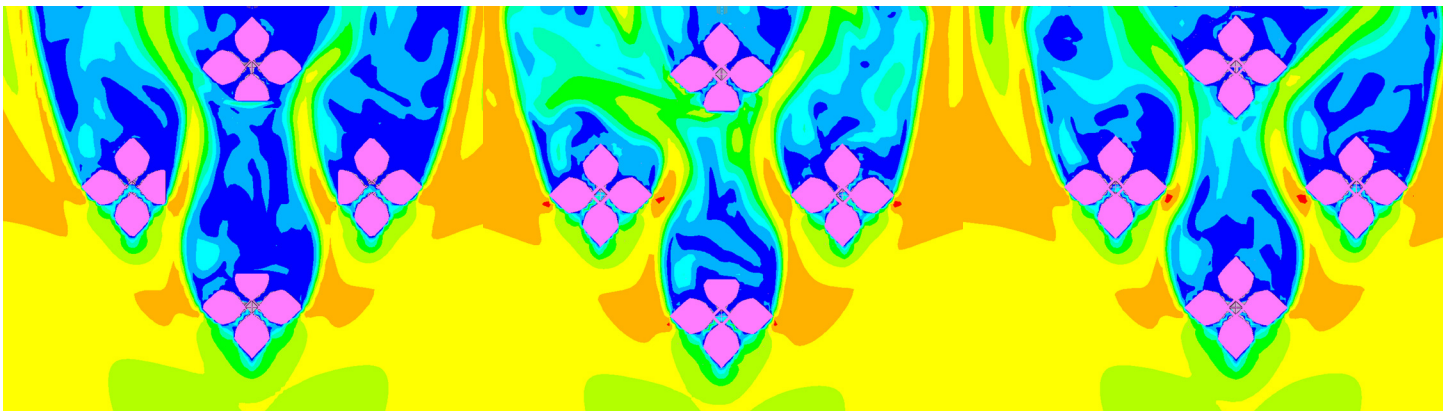


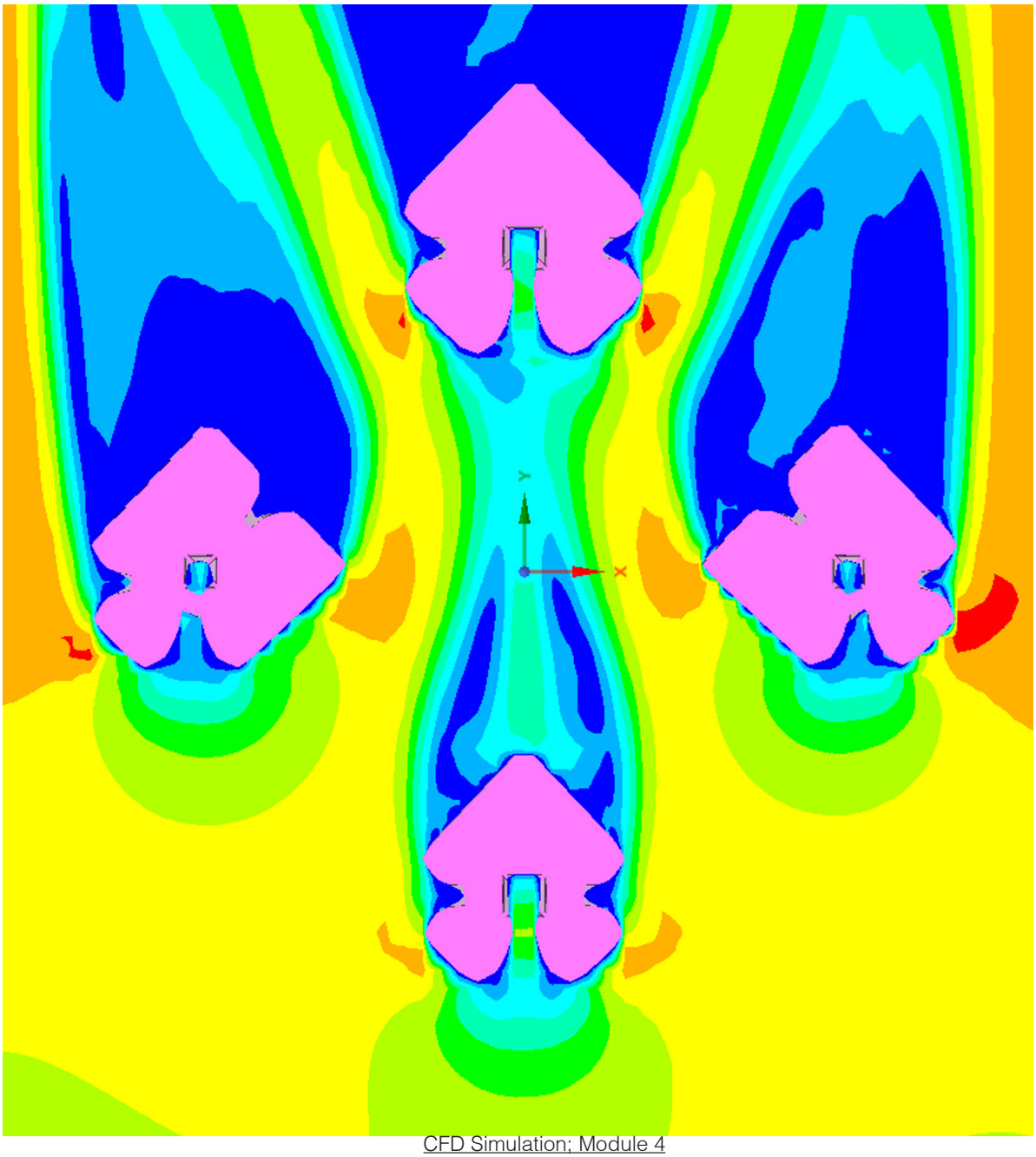
Phase 1; Embodiment

Axonometric view

Phase 1b_4 Modular Design

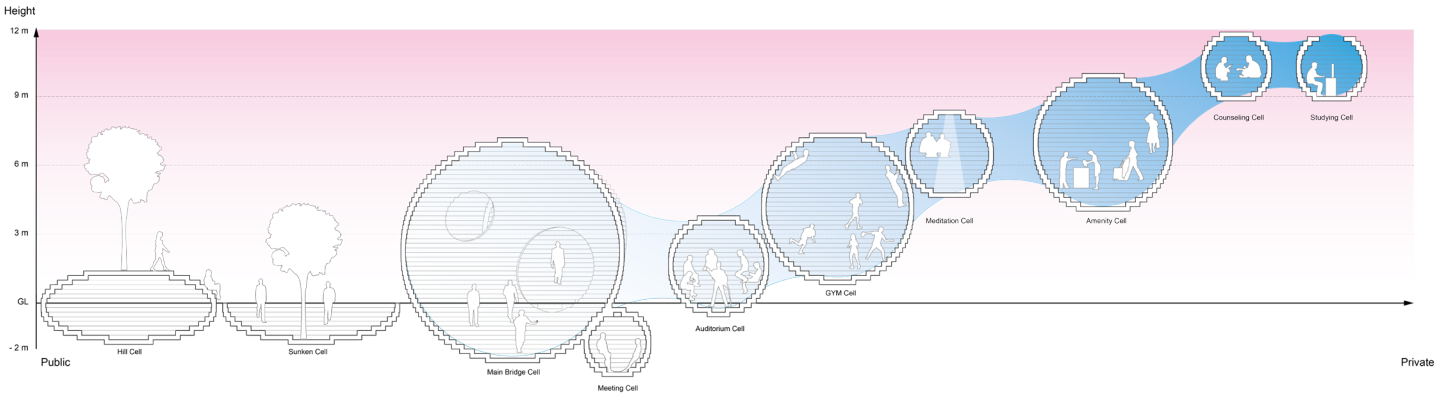
Based on configuration of single modular design, 4 collective modules will re-shape the public space with fresh air. The each shape of the modulars maximize the chance to get pollutant air through CFD simulation.

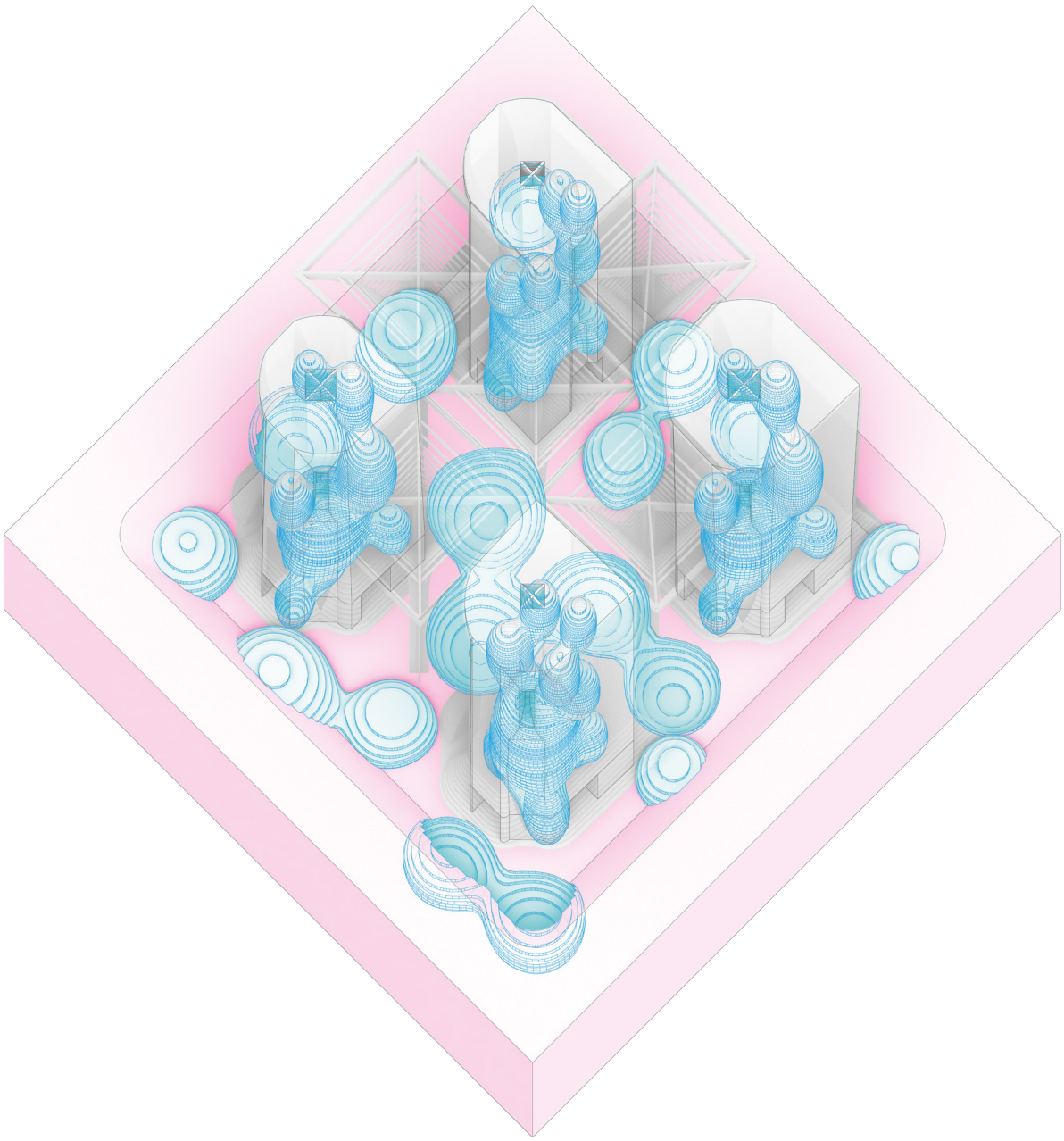




CFD Simulation; Module 4

Wind path configuration for 4 building





Phase 2: Embodiment

Axonometric view

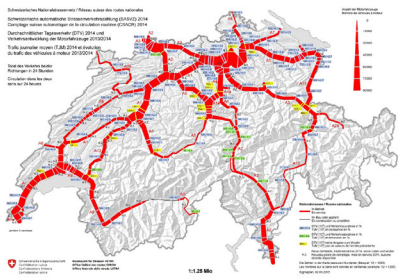
Phase 1a & 1b

Based on CFD simulations, the project is comprised of air cell spaces to provide best air quality to the public. The fresh air will not only circulate interior areas, but would also be released to the exterior public plaza around the modules..

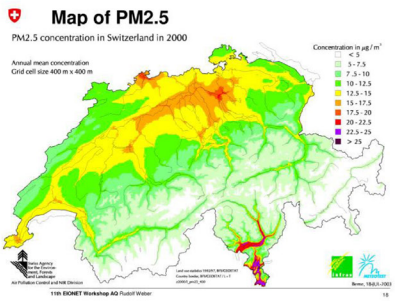
Phase 2_Clinic Design in Geneva

Phase 2 expands the idea developed in the first phase in a more specific site with programs. Geneva's dominant air pollutants include PM2.5 and NO2 due to the high volume of vehicles.

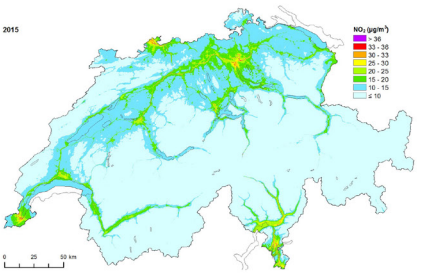
Traffic Volume

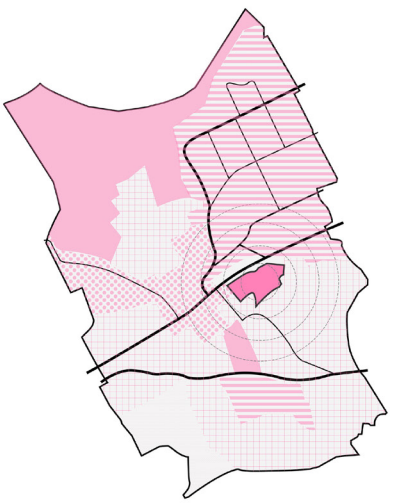


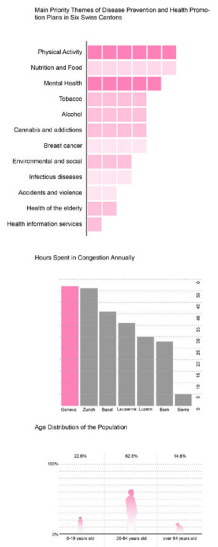
PM2.5 Emission

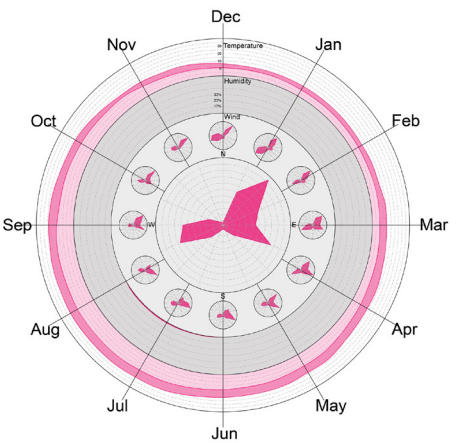


NO2 Emission



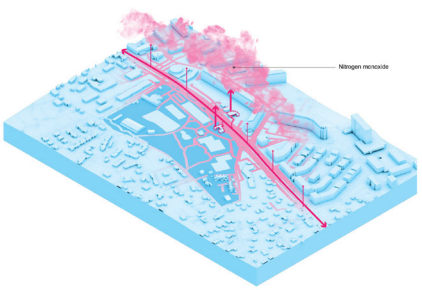


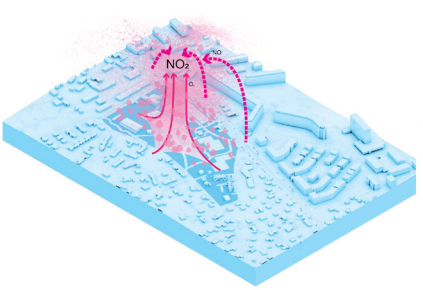


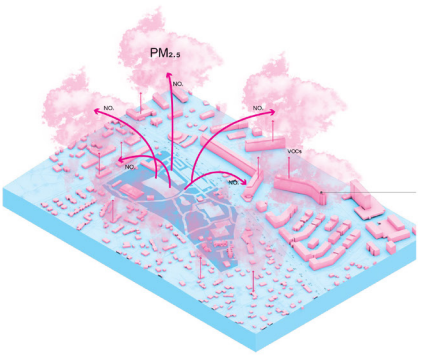


Different density of residential area

Onex Condition Information







1. Nitrogen Monoxide created by vehicles

2. Nitrogen Monoxide combined with Oxygen, and produce Nitrogen Dioxide

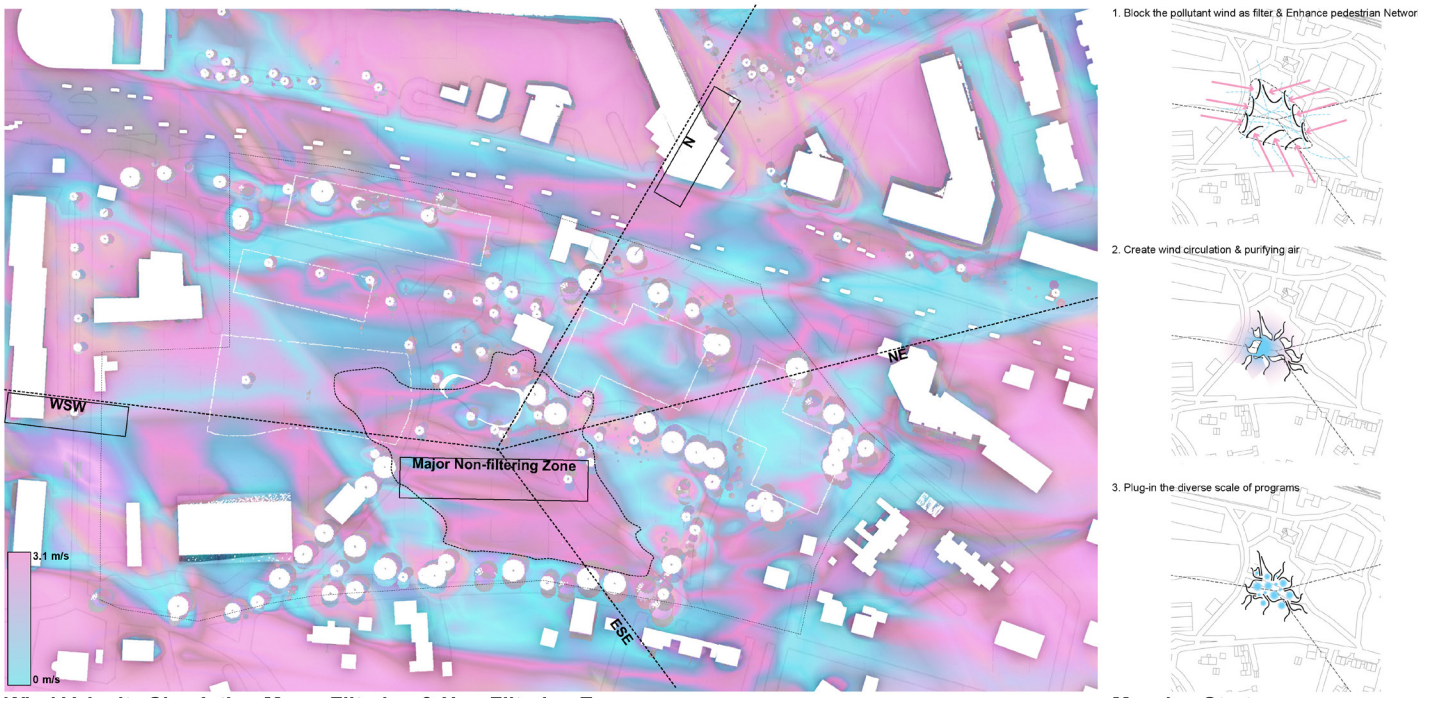
3. Nitrogen Dioxide additionally combined with VOCs from residential area and create particle matter pollutant

Onex Air Pollution Research

Extract major wind direction and pollutants in the air

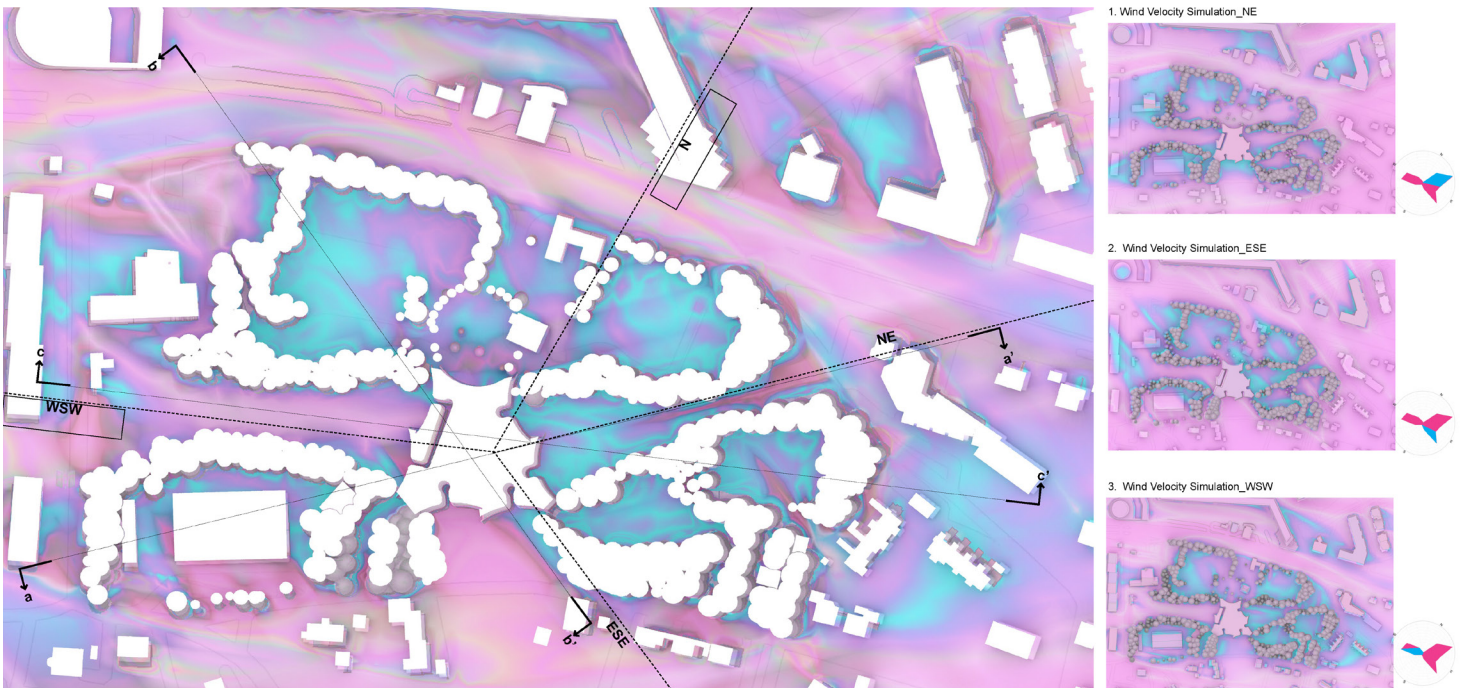
Re-shape the phenomenon in the Parc Brot

The site is located in a park, and the location of the building is considered through a wind velocity map. High wind velocity represents non-filtering zone, which means that it contains high density of pollutants than other zones. Thus, the clinic is put in a major non-filtering zone so that it reacts as the major air filter inside the park.



Wind Velocity Map_Original Site

Filtering & Non-Filtering Zone

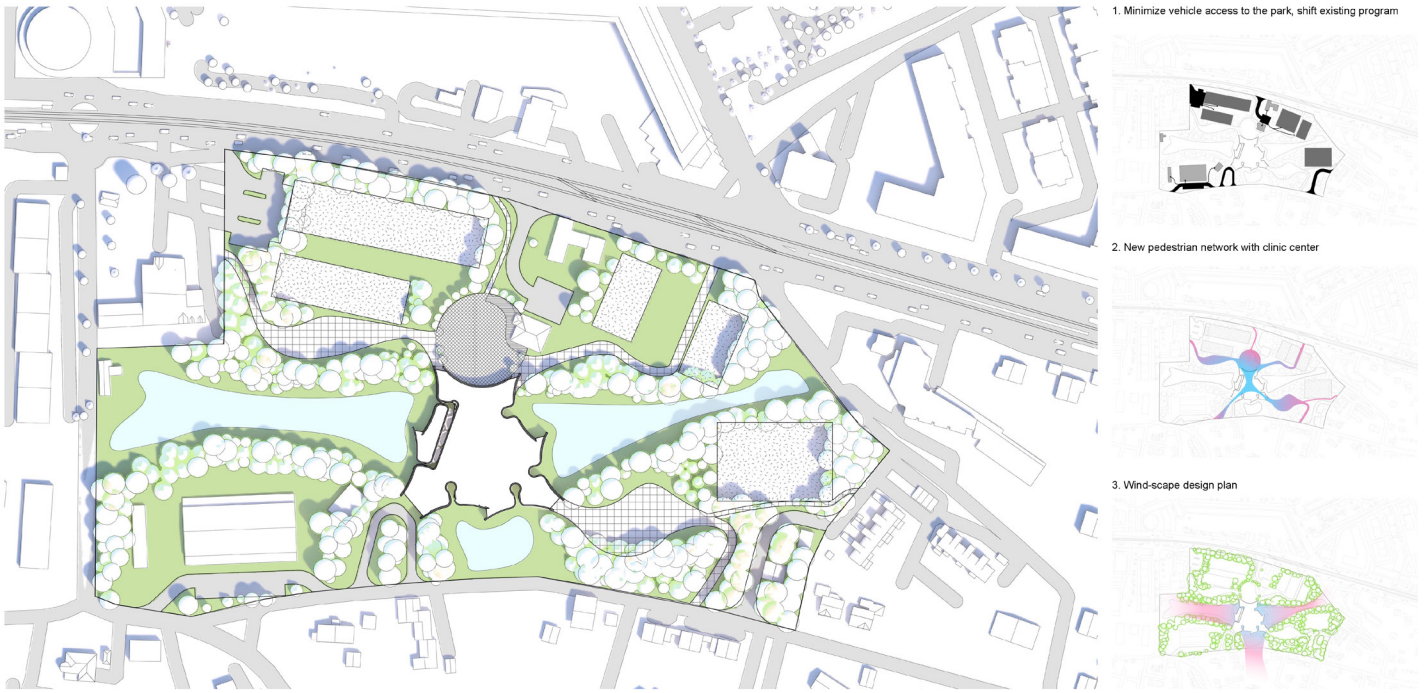


Site Plan;Re-shape Wind-scape

Maximize filtering zone on the park and bring pollutant wind to building

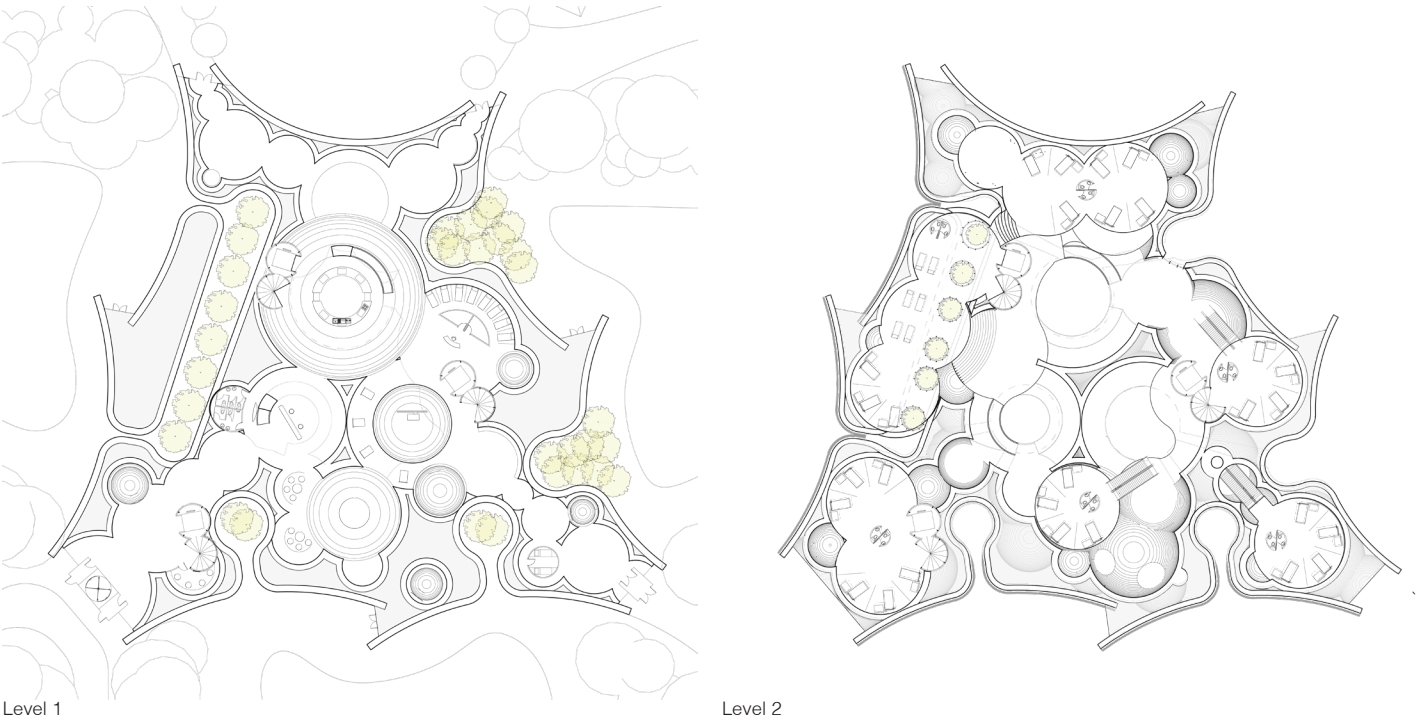
Embodiment_Phase 2

The project proposes air shell clinic as the major filter of the park to care for the visitors' mental health through fresh air. The different scales of air shell spaces continuously create circulation of fresh air for visitors and provide various spaces and clinical programs.



Site Plan

Blending with new clinic

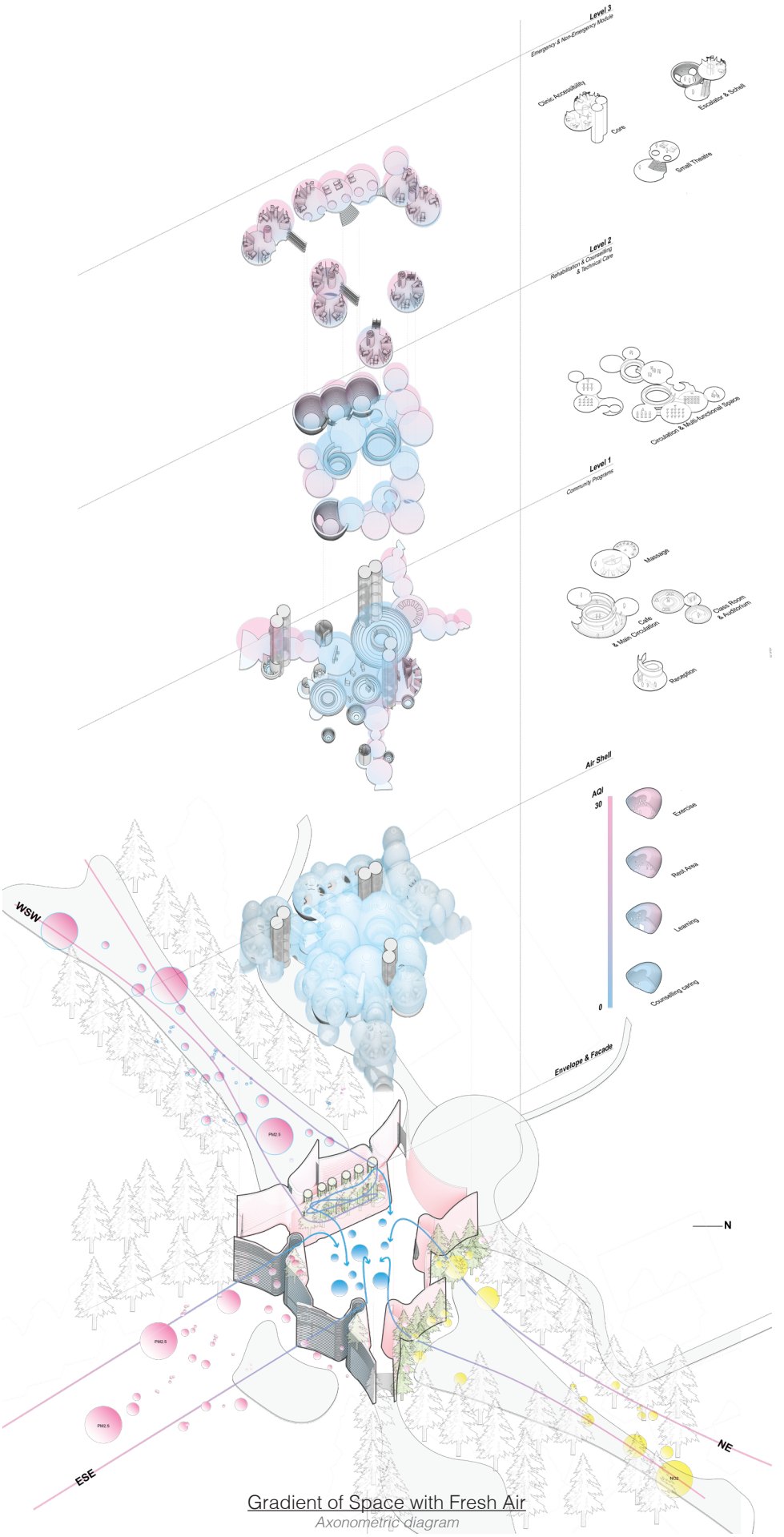


Level 1

Level 2

Plan

Relationship and sequence of programs in the air shell



Gradient of Space with Fresh Air

Axonometric diagram

Embody the Space Through Simulation

The simulation is a medium, which not only enables architecture to engage with air pollution phenomenon, but also bridges between architectural idea and realization.

02 Liquid-scape
BUFFALO IMAGE SCAPES

-Cornell AAP
-Option Studio
-Fall 2018

Site : Buffalo
Instructor : John Zissovici

Olmsted Park in Buffalo, New York -- although it is originally designed as a metropolitan recreational space and introduced the parkway to the American cityscape, the park is losing its role as the main recreational space in the city, due to the emergence of highways. Since the Industrial Revolution had constructed Scajaquada Expressway and Delaware Avenue at the middle of the park, fast-speed vehicles disconnected the park's programs and diminished visitors' accessibility and connectivity. A new landscape design is required to remedy this situation.

The project studies how the speed can be captured, simulated into the new landscape design and the simulation's positive impacts. As the highway had taken away the opportunity to fully enjoy the recreational activities in the park, the project sought to transform the speed itself into a new recreational experience and provide information for the visitors as a compensation.

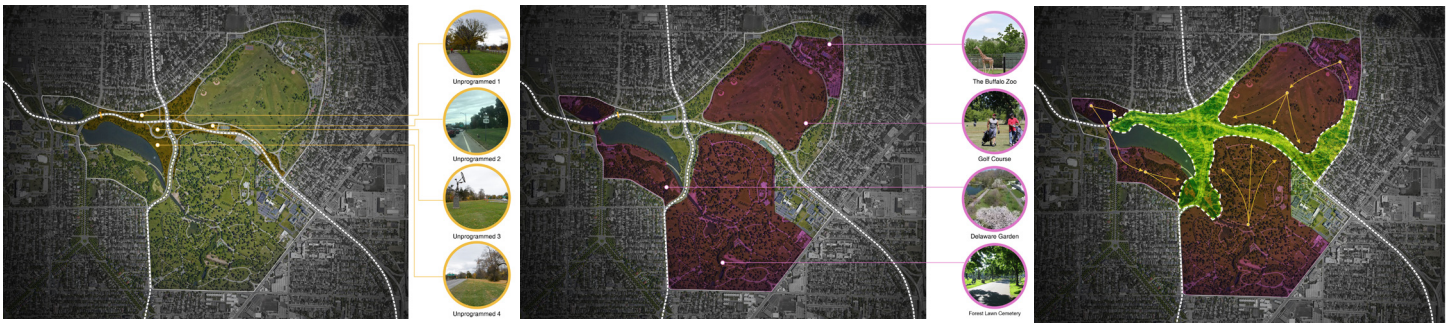
Therefore, this project proposed Liquid-scape around the highway as the park's new recreational program. The diverse speeds will be captured by a liquid surface, transformed into wave patterns, and displayed through the Augmented Reality. The Liquid-scape will create different wave patterns based on objects' directions, speeds, and volumes, and the massive highway will be camouflaged by the new topography in the park.

Specifically, Liquid-scape transforms speed into a green wave pattern, and it provides additional experiences, enhances the existing recreational activities and memorizes the traces of speed in the highway in three phases. The first phase, AR Liquid-scape condition makes pedestrians encounter Liquid-scape, providing opportunities to discover different landscape wave topographies every second. It also gives an opportunity to observe and mediate in the middle or at the end of their journey. In the second phase, the section line of wave patterns will transform into linear bench in un-programmed zones and landscape design will physically reflect vehicles' speed as auditoriums and light fixtures. Lastly, the third phase captures the overall vehicle's wave patterns and send them to the database. These patterns will be reloaded after a certain period when the highway is deconstructed in the near future and Liquid-scape will exhibit, memorize and celebrate the trace of speed for the public.

The existing fast speed in the highway now will be part of landscape elements at Olmsted Park through this hybrid landscape design. In the future, when highways disappear, the Liquid-scape will reintegrate all parts of the park as the main central entertainment program in Buffalo.

High Way_Unusual speed at the Park

The project attempts to transform highway's fast speed into another landscape program through the media. Based on the existing recreational programs, Liquid-scape will be installed at current non-programmed area in the park.

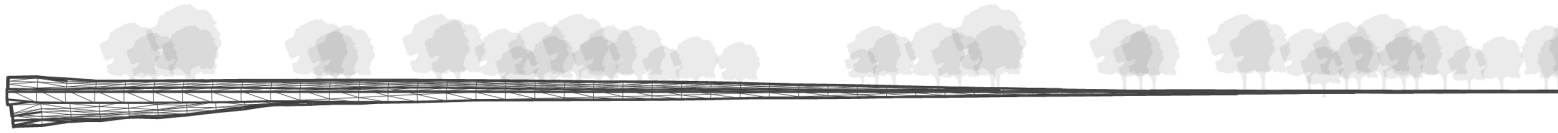


Speed;Park Boundary

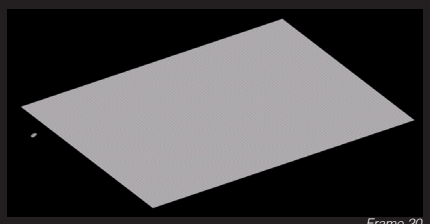
Set the boundary of Liquid-scape

Liquid-scape_Tracing the Speed Through Different Wave Pattern

The idea starts from creating the third Liquid condition using AR to capture different speeds. Liquid surface simulation enables the project to understand how speed will provide diverse moments with wave patterns and explores how the new program will have positive impacts on the existing park activities.



Direction



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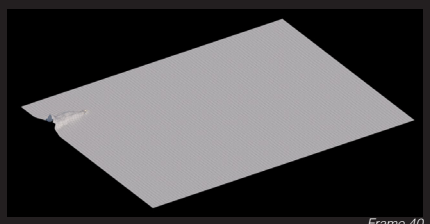

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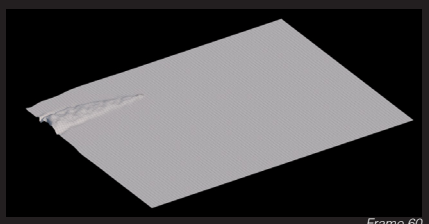

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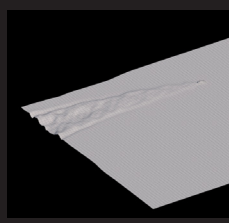
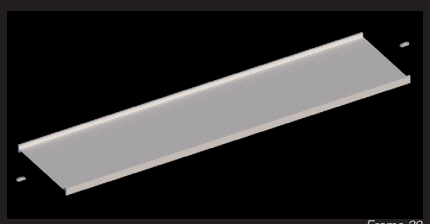


Resonance



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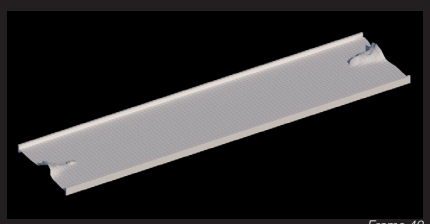

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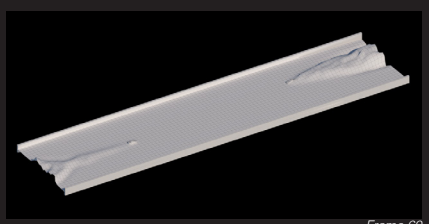

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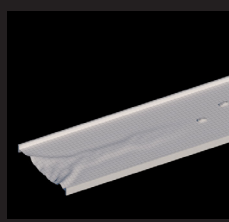
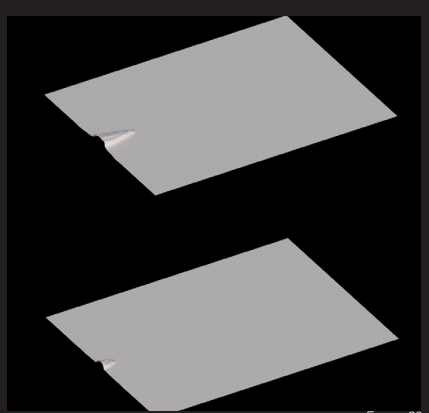


Different Speed



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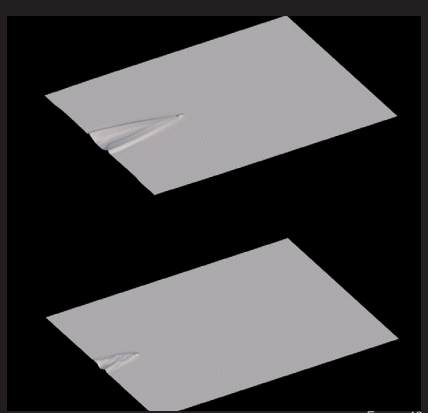

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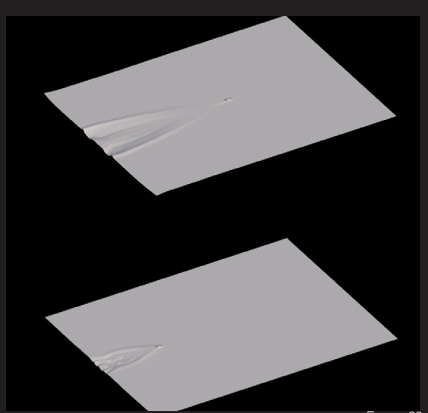

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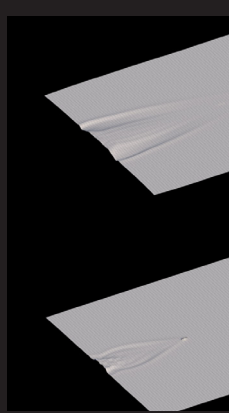

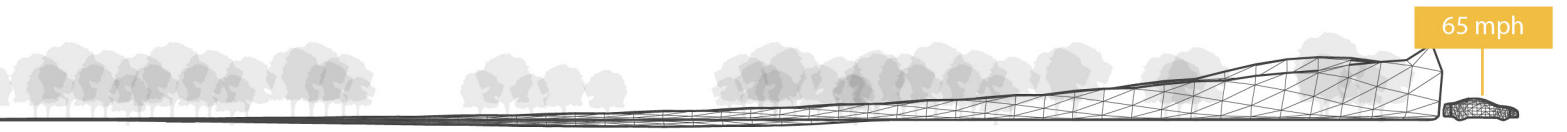

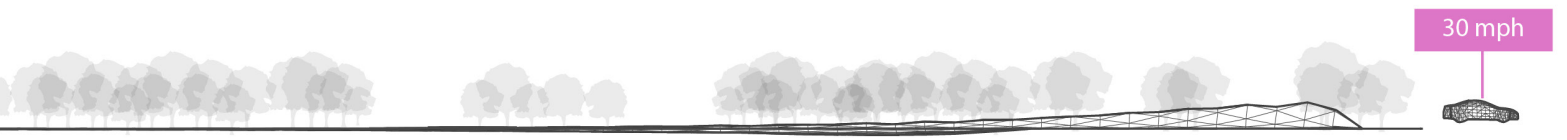

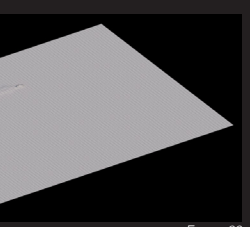
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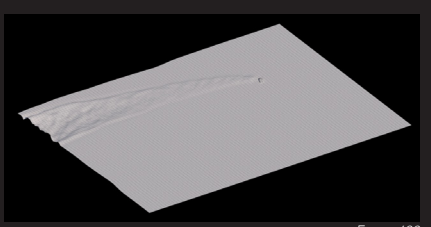
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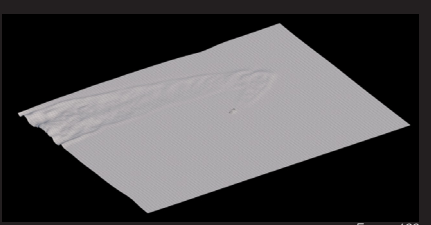
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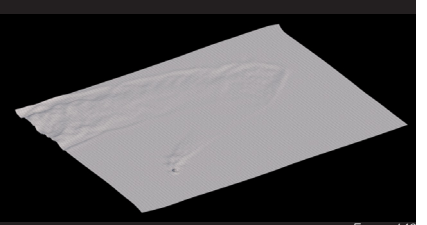
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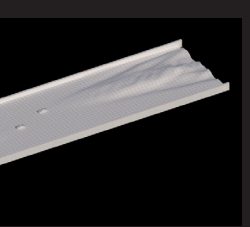
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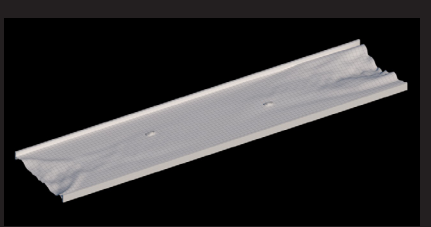
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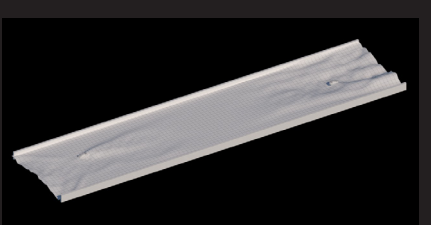
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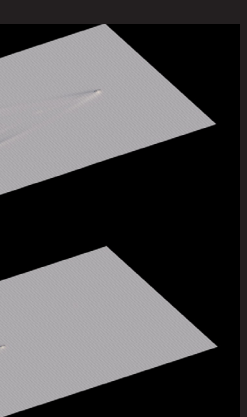
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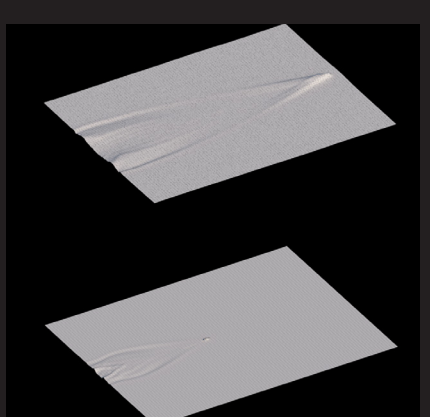
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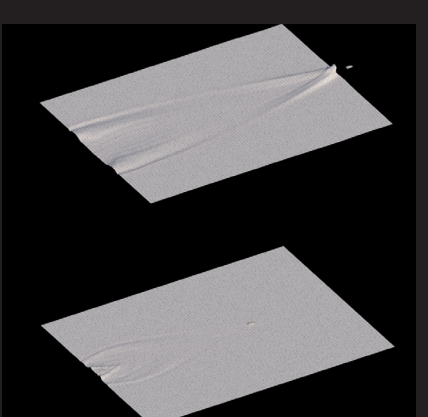
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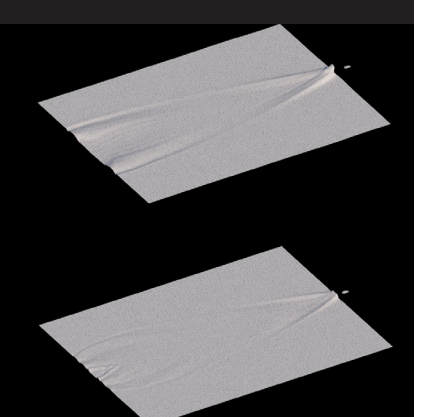
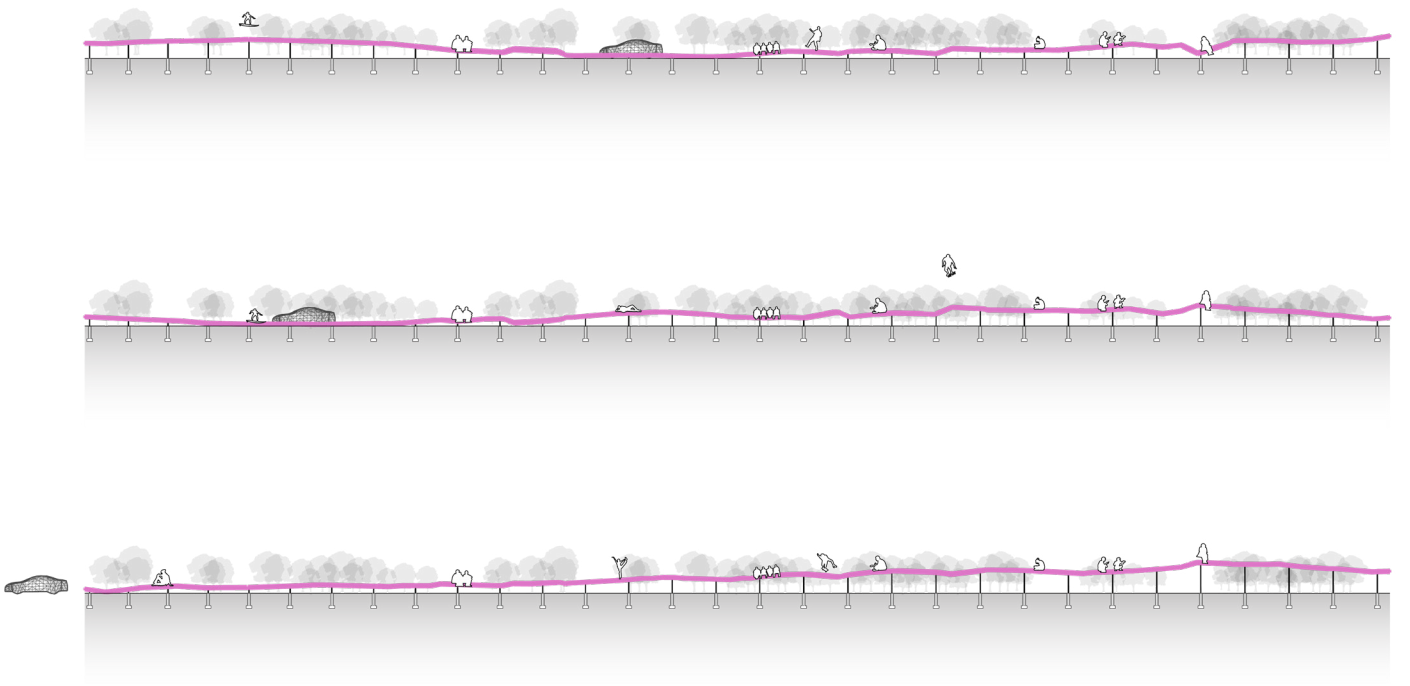

Frame 140

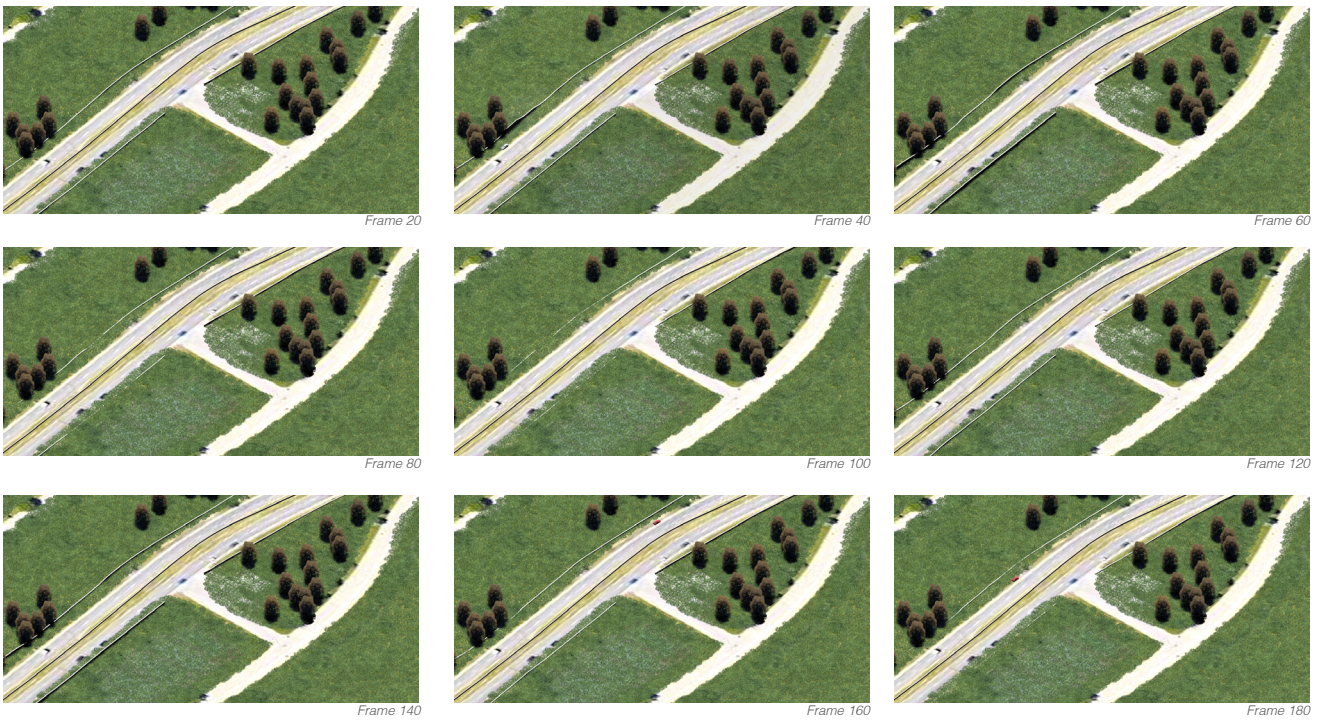
Liquid-scape_Expend the Boundary from AR to Real World

The project not only exhibits the speed through Augment Reality(AR), but also physically impacts the existing park. The section profile will be reflected as benches around the highway and create new recreational events such as an amusement park, and enhance existing programs like the auditorium.



Phase 2; Physical Impact of Liquid-scape

Liquid-scape section profile transform into bench



Simulation; AR transformed into real world

Enhance the existing recreation activities

03 Cornell Summer Workshop
AAP New York Center Studio

-Cornell AAP
-Summer Studio
-Summer 2018

Site : New York
Instructor : Tei Carpenter, Jesse LeCavalier

New York City is an urban laboratory and a site for the first semester of Cornell AAP's advanced design research program for M.S.AAD. The program makes full use of the city's intellectual and creative resources, as well as its dilemmas and challenges to introduce students to terms, techniques, and problems of contemporary design inquiry. The intensive eight-week curriculum comprises of a design studio and seminars that offer an overview of the program's three territories of investigation; Architecture and Urbanism(A+U), Architecture and Ecology(A+E), Architecture and Discourse(A+D).

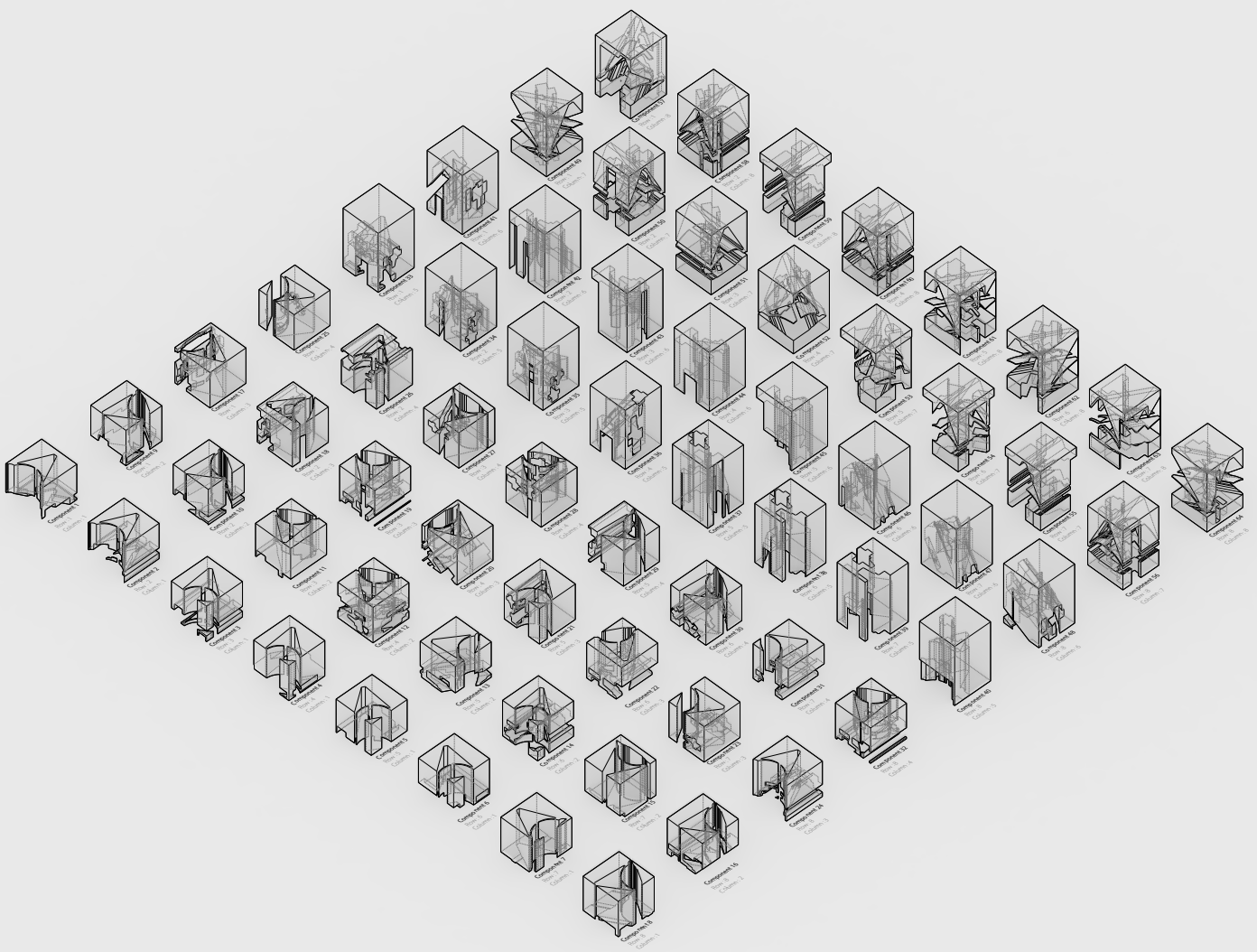
The design research workshop during the summer semester, based on Axel Kilian's lecture, explores how algorithm and embodied computation can be used in architecture. The workshop focused on understanding and establishing algorithm which enables architecture to be transformative and interactive based on inputs and outputs. The project attempts to achieve interactive pavilion design through combination of architecture and robotic technology . Depending on the number of users or time of the day, the pavilion automatically adjusts to embody different profiles for the users.

The coding enabled us to not only analyze the big data from urban condition, but also calculate and formulate the numerous possibilities of building profiles. We used this tool to simulate various iterations during Architecture and Ecology (A + E) studio workshop projects. This workshop explored an expanded idea of ecology that encompasses not just the natural environment but also the entanglements of human-made products and byproducts within its definition. We tested, explored, and expanded the building formation based on our architectural ideas.

This chapter mainly discusses about the possibility of engagement between architecture and computation as a tool of embodiment and how those new technologies can be utilized in the design process.

Future Oriented Protein Cultivation

Site : Roosevelt Island, New York, NY
Architecture + Ecology
Group 6



Prototype 1
Conical Cenotaph of the Sepulchral Chapel, Etienne-Louis Boullée, 1786

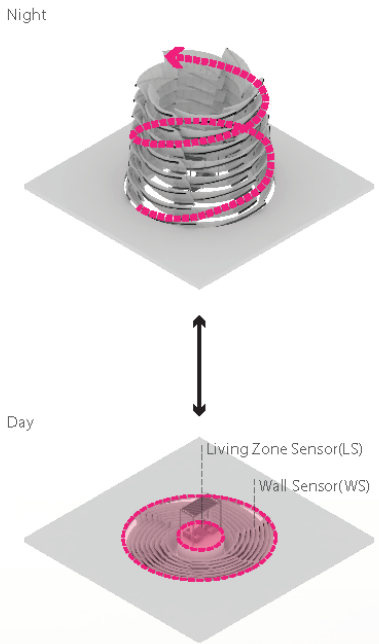
Prototype 2
Tokyo Opera House, Jean Nouvel and Philippe Starck, 1986

The project proposes a flexing pavilion established through an algorithm. The robotic technology enables architecture to react with specific conditions through sensor, and automatically formulate its form (output) based on the different input condition.

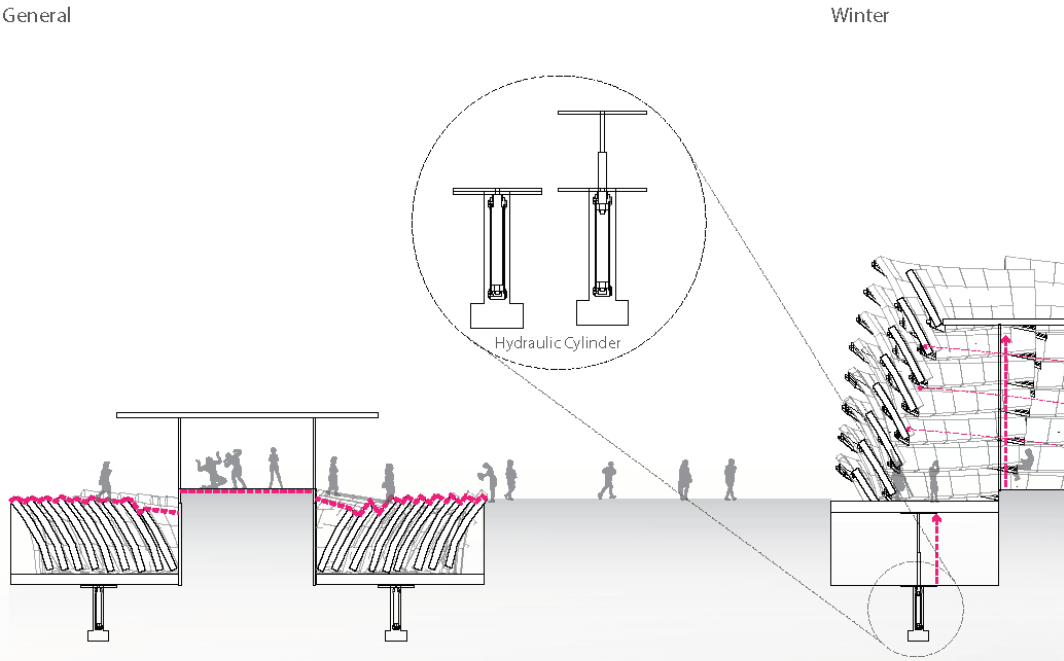
ARCH 6301C Design Research

Embodied Computation - The Flexing Room Architectural Robotics

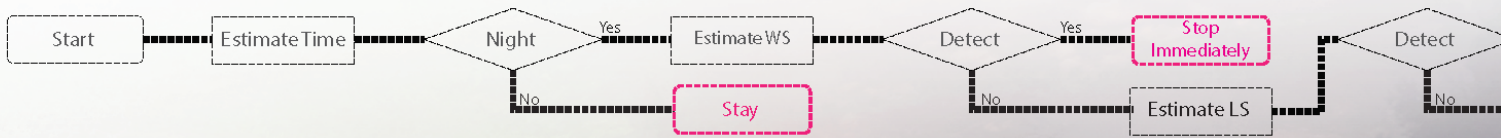
Basic Principle



Flexing Room Process

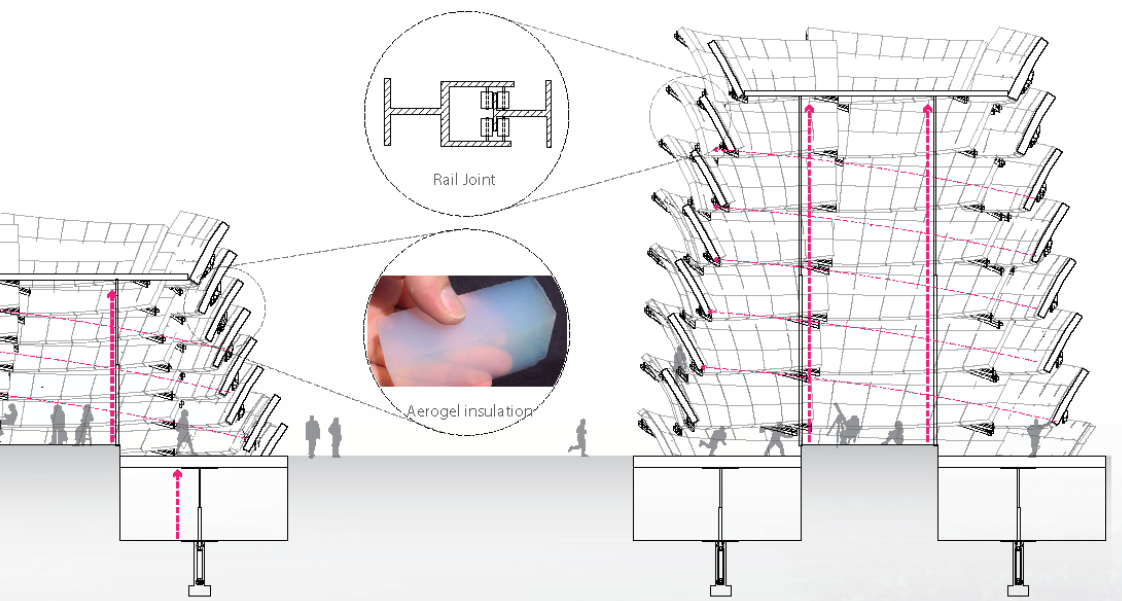


Sensor Process



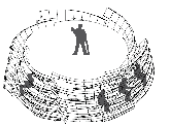
Program Formation

Summer

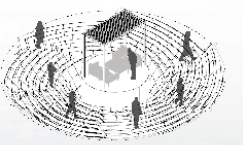


Lighting Fixture

Auditorium

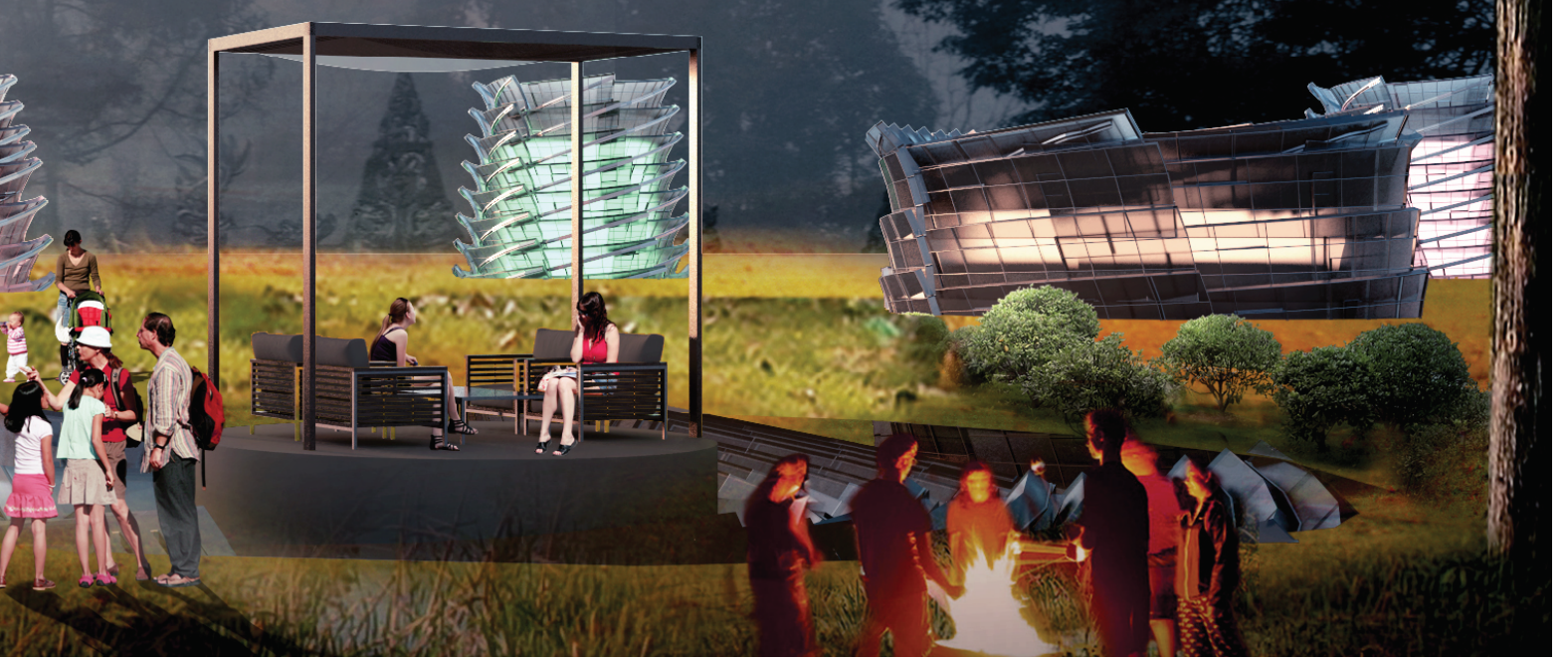


Exterior Terrace



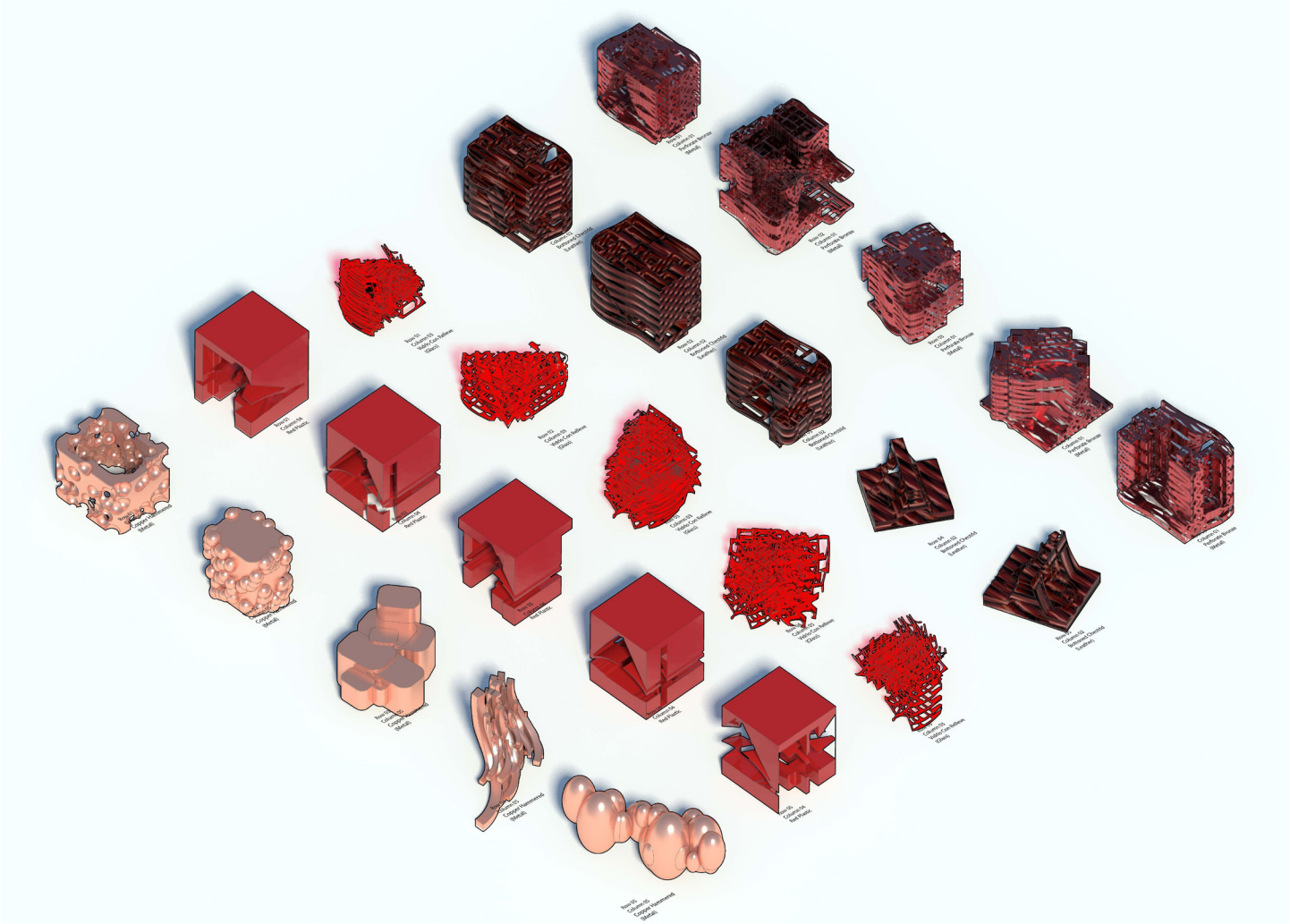
Spiral Flexing Room

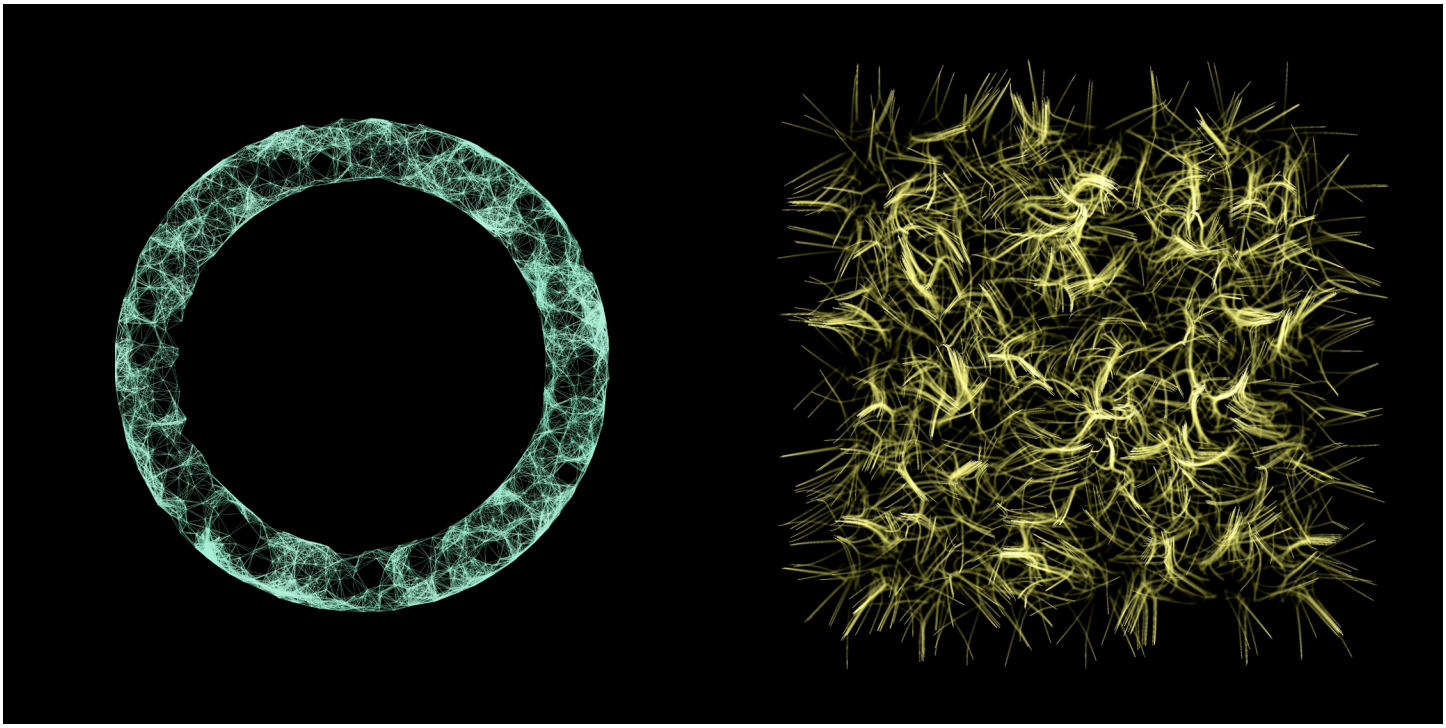
The spiral structure enables space to not only change its form but also control the living quality, such as light, ventilation, and temperature through the multi-layered wall system. With autonomy technology, Spiral Flexing Room system would interact with people and the environment and provide the best quality of space depending on users and situation.



Coding_Test, Explore, Calculate the Architectural Data

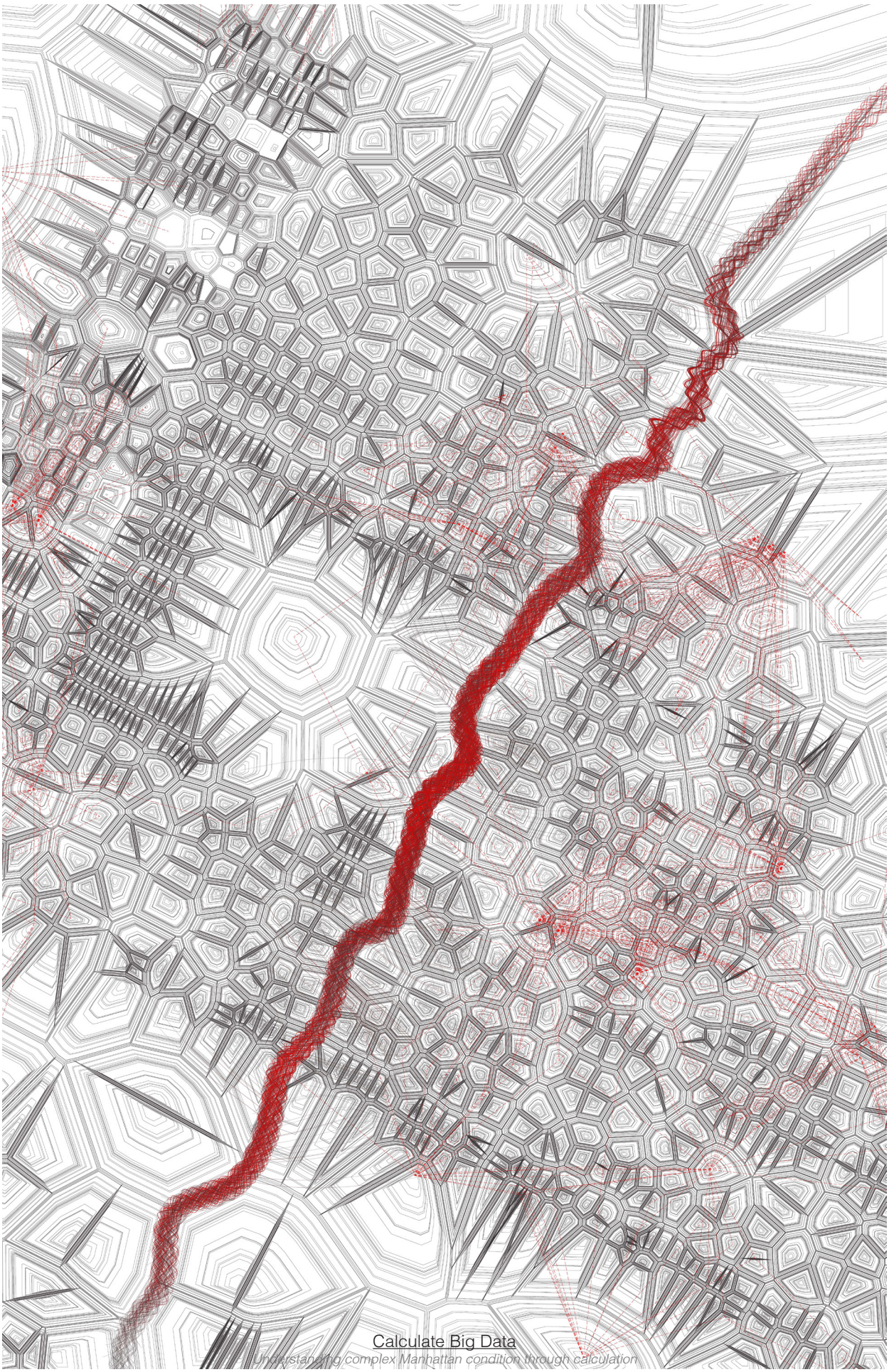
The new technology now enables us to understand complex urban condition through calculation, not from personal assumptions. Furthermore, it allows us to enhance our idea process and embodiment of architecture through numerous iterations.





Catalogue through Coding & Embodiment

Calculate best option through test

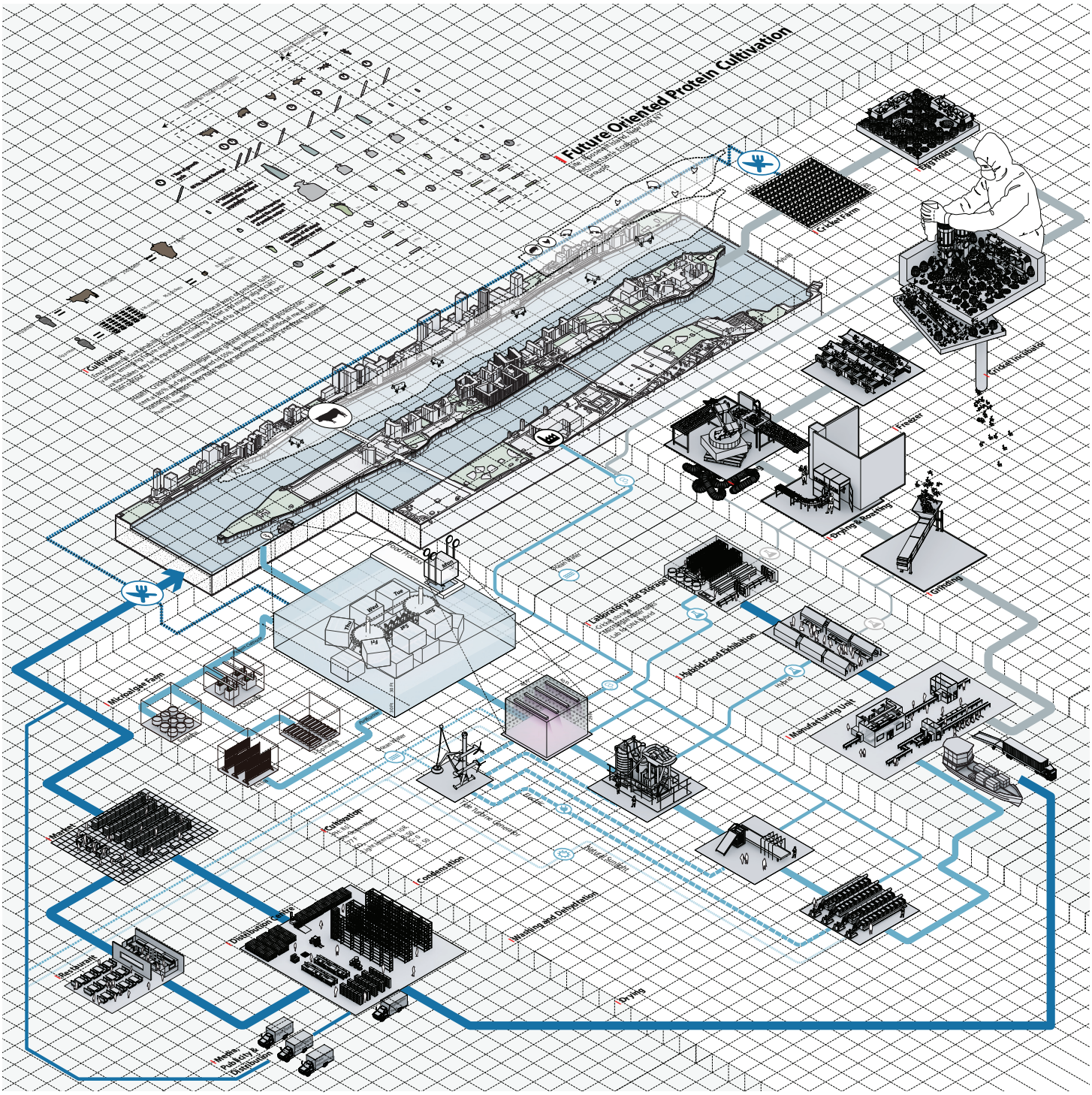


Calculate Big Data

Understanding complex Manhattan condition through calculation

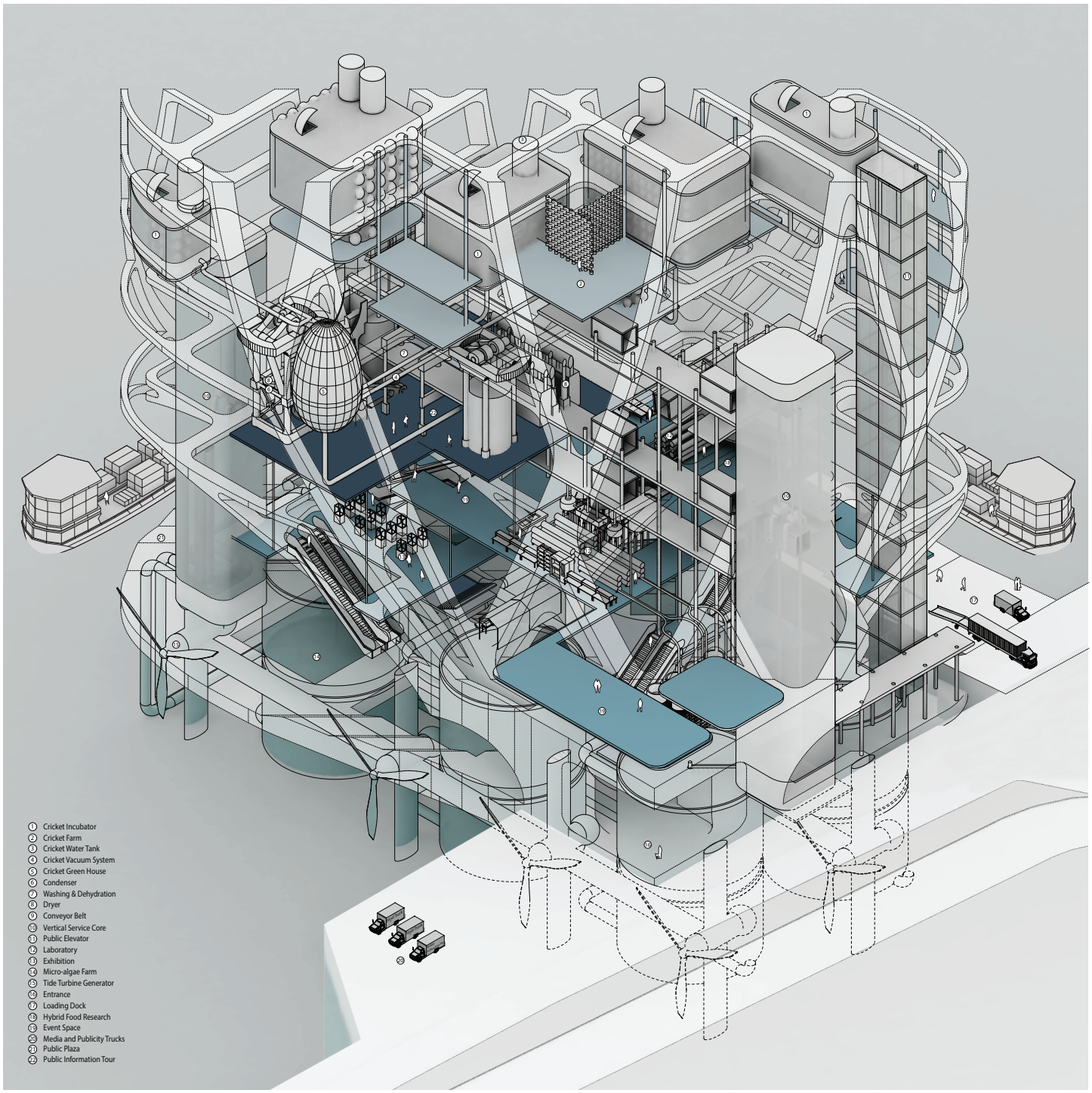
Architecture and Ecology; Roosevelt Island Future Protein Factory, New York

The project proposes futuristic protein cultivation factory on Roosevelt Island, New York. Compared to traditional ways of protein cultivation, emerging future cultivation methods using cricket and micro-algae require less input of land, water and nutrition. Moreover, Crickets and micro-algae have greater percentage of protein content than traditional meat cultivation. This new hybrid factory will alleviate national pollution crisis and eill be beneficial for ecological systems and human life



System Configuration; Cricket and Micro-algae

Sustainable circulation of processing proteins between crickets and micro-algae.
Produce the foods, create the energy and purifying the water

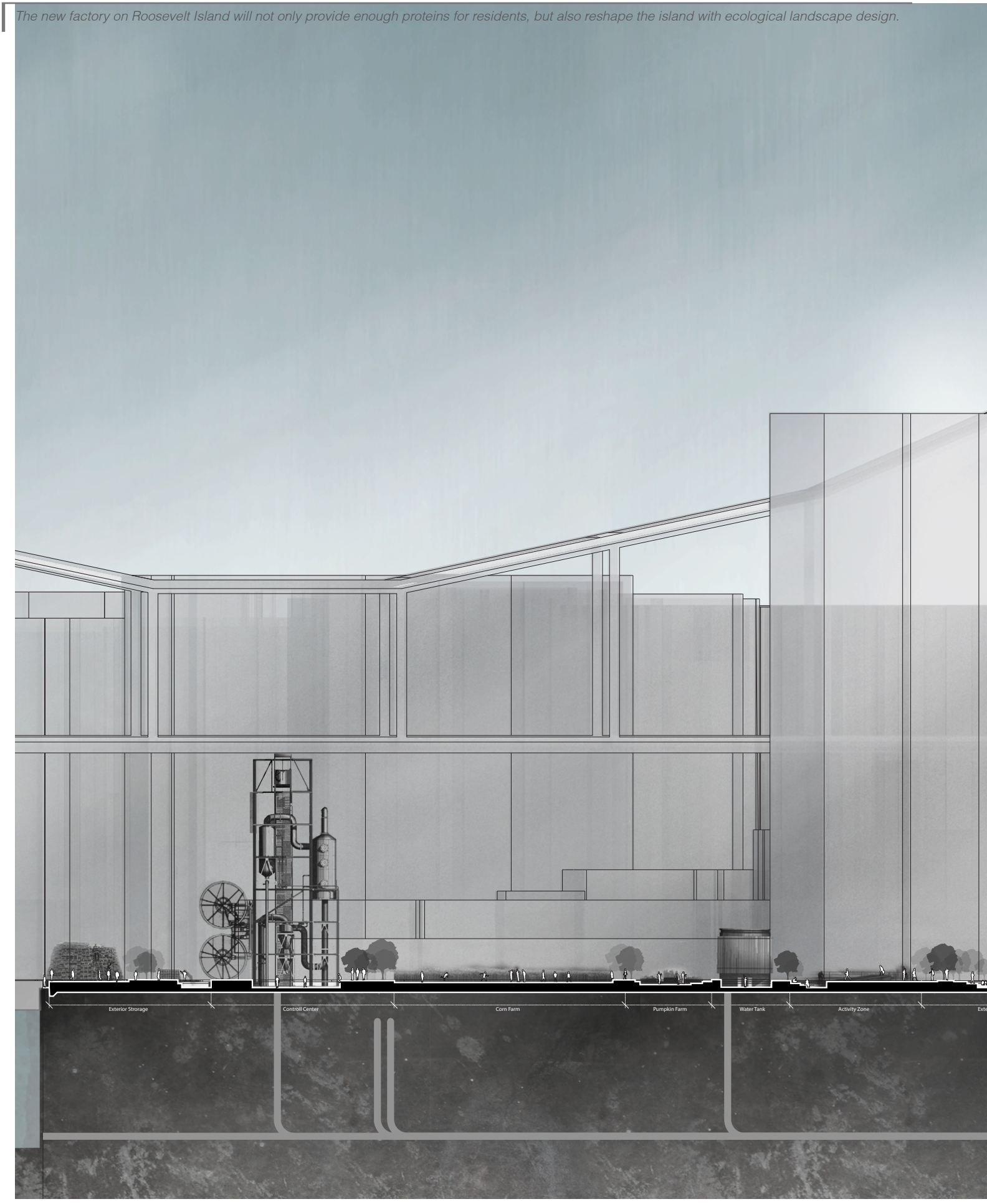


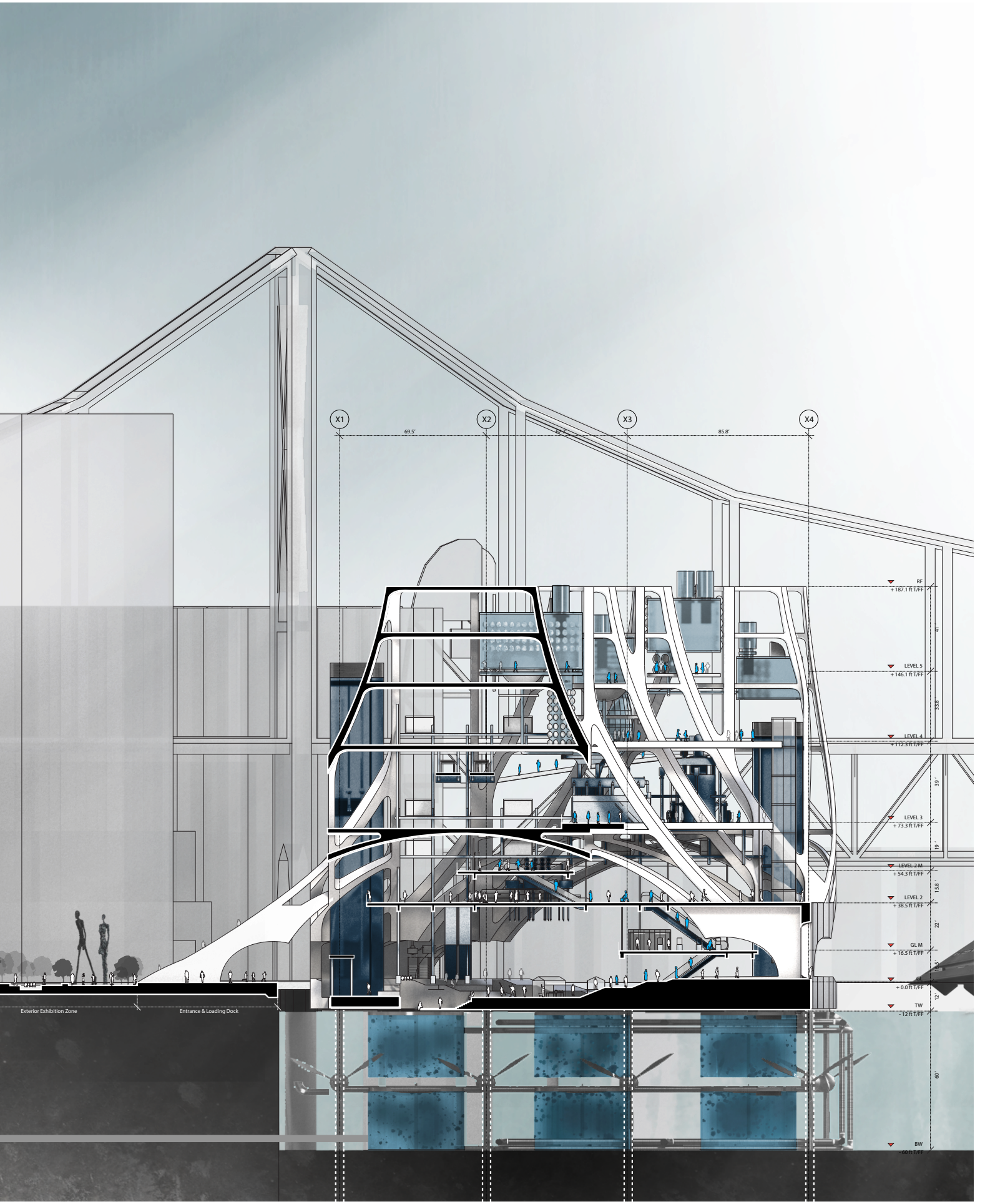
Hybrid Protein Factory

Open factory will exhibit the process of creating proteins and provide the place to share or taste the future food for public on the ground level.

Architecture and Ecology; Roosevelt Island Future Protein Factory, New York

The new factory on Roosevelt Island will not only provide enough proteins for residents, but also reshape the island with ecological landscape design.




X1
X2
X3
X4
69.5'
87.2'
85.8'
RF
+ 187.1 ft T/FF
LEVEL 5
+ 146.1 ft T/FF
LEVEL 4
+ 112.3 ft T/FF
LEVEL 3
+ 73.3 ft T/FF
LEVEL 2 M
+ 54.3 ft T/FF
LEVEL 2
+ 38.5 ft T/FF
GL M
+ 16.5 ft T/FF
GL
+ 0.0 ft T/FF
TW
- 12 ft T/FF
BW
- 60 ft T/FF
41'
33.8'
39'
19'
15.8'
22'
4.5'
12'
60'
Exterior Exhibition Zone
Entrance & Loading Dock

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